PB87-190880

Multimedia Approaches to Assessment and Management of Hazardous Air Contaminants

(U.S.) Environmental Protection Agency
Research Triangle Park, NC

Mar 87

U.S. Department of Commerce
National Technical Information Service
NTIS

PB87-190880

EPA/600/8-87/012
March 1987

Multimedia Approaches to Assessment and Management of Hazardous Air Contaminants

A Report From NATO/CCMS Workshop Denver, Colorado, USA October 8-10, 1986

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Meeting and Report Provided Under Contract No. EPA 68-02-4191

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SPRINGFIELD, VA 22161

TECHNICAL REPORT DATA (Please read Instructions on the reverse before completing)		
1. REPORT NO. EPA/600/8-87/012	2.	3. RECIPIENT'S ACCESSION NO. PB87 190880/AS
4. TITLE AND SUBTITLE Multimedia Approaches to Assessment and Management of Hazardous Air Contaminants		5. REPORT DATE March 1987 6. PERFORMING ORGANIZATION CODE EPA/600/23
7. AUTHOR(S) F. Vandiver Bradow, ECAO, RTP, NC 27711 Anne H. Appe, Dingle Assoc., Washington, DC 20006		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Environmental Criteria and Assessment Office (MD-52) Office of Health and Environmental Assessment U.S. Environmental Protection Agency Research Triangle Park, NC 27711		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Office of Health and Environmental Assessment (RD-689) Office of Research and Development U.S. Environmental Protection Agency Washington, DC 20460		13. TYPE OF REPORT AND PERIOD COVERED Special Report 14. SPONSORING AGENCY CODE EPA/600/21
15. SUPPLEMENTARY NOTES A report from NATO/CCMS Workshop, Denver, Colorado, October 8-10, 1986		

16. ABSTRACT For 15 years, the North Atlantic Treaty Organization's Committee on the Challenges of Modern Society developed information on air pollution research and control through a series of studies. As a non-defense activity of the Alliance, the NATO/CCMS became a focal point for scientific communication. At the completion of the study series in 1984, member nations agreed to conduct five annual follow-up workshops to maintain the network of technical information exchange. The first workshop, on advanced monitoring techniques, was held in October 1985; the Environmental Criteria and Assessment Office hosted the second, "Multimedia Approaches to Assessment and Management of Hazardous Air Contaminants," on behalf of EPA and the USA. The workshop was designed to widen the horizons on air pollution professionals to include cross-media aspects. Using lead as a paradigm for multimedia pollution, the workshop examined case studies illustrating difficulties and successes in reducing human exposure. Placing special emphasis on decisionmaking in the face of uncertainty, the several sessions looked at methods for multimedia assessment and management of risk. Participants developed a set of recommendations for NATO/CCMS consideration dealing with the complex nature of integrated assessment and management, including comparability and coordination of methods, research to quantify uncertainty in risk assessment methodologies, more effective means of communicating risk to the public, and organizational and legislative structures more responsive to the need for integrated management across all media.

17. KEY WORDS AND DOCUMENT ANALYSIS		
a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
18. DISTRIBUTION STATEMENT Release to Public	19. SECURITY CLASS (This Report) Unclassified	21. NO. OF PAGES 125
	20. SECURITY CLASS (This page) Unclassified	22. PRICE

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

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ACKNOWLEDGMENTS

The support and interest of EPA's Regional Administrator, John Welles, contributed greatly to the success of the Denver workshop. The assistance of Denise Link, Max Dodson, Steve Frey, Debbie Anderson and Jean Parker was especially helpful. The Region 8 chapter of EPA's Women in Science and Engineering graciously hosted a participants' reception. Chip Duke of Northrop Services, Inc. (NSI) did a noteworthy job demonstrating the REFEREE bibliographic database system and providing other microcomputer support. The considerable time and effort spent by Robert Bauman (U.S. EPA) in leading the group's development of recommendations, and Lyn Schoolfield (U.S. EPA) in facilitating are especially appreciated. The contributions of Toni Schneider of The Netherlands in summarizing the many workshop presentations are also acknowledged. Editing and graphics support provided by Allen Hoyt of the Environmental Criteria and Assessment Office, and word processing by Miriam Gattis and Lorrie Godley (NSI) are gratefully acknowledged. Technical support to both the workshop and report development was provided by Dingle Associates, Inc.

PREFACE

Since its inception in 1969, NATO's Committee on the Challenges of Modern Society (CCMS) has been involved in environmental concerns. For 15 years, the NATO/CCMS Air Pollution Pilot Study series developed information on air pollution control strategies and impact modeling. At the completion of the series in 1984, the Federal Republic of Germany proposed a series of follow-up workshops that would address specific issues identified during the course of the air pollution pilot studies. The workshops would maintain the network of technical information communication which had developed through the pilot studies, and would provide a forum for considering problems of international scope.

The first workshop was held in Lindau, Federal Republic of Germany, in October 1985. The topic was advanced air pollution assessment methods and monitoring techniques. The second workshop, summarized in this report, took place in Denver, Colorado, in October 1986, and was hosted by the Environmental Protection Agency on behalf of the United States of America. The workshop's theme was multimedia approaches to risk assessment and management of hazardous air contaminants.

The workshop was designed to challenge air pollution research and control professionals to consider the broader context of environmental pollution. As many countries are beginning to understand, measures to safeguard public health and the environment will often require an integrated approach in order to be effective. This workshop offered an opportunity for exploring various countries' efforts toward developing such integrated, multimedia approaches to assessing and managing air pollutants.

I. INTRODUCTION

The implications of air pollutant control beyond the domain of the atmosphere represent a new challenge for air pollution professionals. Thus, the NATO/CCMS Workshop's purpose was to provide an opportunity for air pollution research and control experts to share information on risk assessment and management, addressing multimedia aspects of contamination. This report is intended to identify the theme, structure, and major points of workshop discussion, and to present recommendations for consideration by national policymakers developed by participants. It is not intended to be a detailed representation of either the presentation or the discussions, nor is it a proceedings document. The chief goal of the workshop was to broaden the perspective of air pollution professionals in workshop session dialogue.

The workshop was attended by about 60 people representing nations both within and outside the Alliance. These countries included the United States, the Federal Republic of Germany, Italy, the Netherlands, Sweden, Canada, and Japan. Experts from each of the participating nations were involved as presenters, panel members, and session leaders. Dr. Michael Berry, U.S. Environmental Agency, and Ms. Christa Morawa, Federal Environmental Agency, Federal Republic of Germany, were overall co-chairs of the workshop.

The workshop used lead as a paradigm for examining difficulties and successes in reducing human exposure to a hazardous contaminant. Following a presentation that summarized the current consensus on scientific opinion regarding lead exposure and effects, a series of case studies was presented. These studies illustrated various countries' experiences in managing lead contamination. The workshop also considered the problems in assessment and management posed by compounds where scientific evidence of health and environmental hazards is less certain than in the case of lead. Other workshop sessions focused on methods for multimedia assessment and multimedia management.

At the conclusion of the workshop, the participants discussed proposed recommendations to national authorities. These recommendations concerned comparability and coordination of methods, research to quantify uncertainty in risk assessment methodologies, more effective means of communicating risk to the public, and organizational and legislative structures more responsive to the need for integrated management across all media.

In addition to the individual presentations, panels, and general discussions, microcomputer demonstrations of REFEREE, an EPA-developed bibliographic database management system, and pMAP©, a geographic information system, were available. Supplementary materials contributed by presenters were also available onsite or by order.

Part II of this report includes a summary overview of the workshop, followed by proposed recommendations developed by the participants and prepared by Robert Bauman of the U.S. Environmental Protection Agency.

Part III is a summary of the 22 workshop presentations, with abstracts submitted by the presenters. In some instances, presenters also submitted complete papers, which have been sent to all workshop participants. For the sake of balance, only the abstracts are included in this report.

II. SUMMARY OVERVIEW AND RECOMMENDATIONS

SUMMARY OVERVIEW

In 1984, with the successful conclusion of a series of air pollution pilot studies initiated and sponsored by NATO/CCMS, the member nations recommended that the information exchange developed and nurtured during the preceding 15 years be continued. A 5-year program of annual workshops, focusing on topical aspects of air pollution control, was suggested and adopted as follow-up to the international air pollution research and control expertise fostered by the pilot studies.

The first follow-up workshop was held in Lindau, Federal Republic of Germany, on October 7-9, 1985, and it dealt with advanced techniques for air pollution measurement.

The second follow-up workshop was held in Denver, Colorado, USA, on October 8-10, 1986. The workshop, entitled "Multimedia Approaches to Assessment and Management of Hazardous Air Contaminants," was designed by its NATO/CCMS co-chairs, Christa Morawa, Federal Republic of Germany (FRG) and Michael Berry, USA, to exchange information helpful to decision-makers in their assessment and management of hazardous environmental pollutants. Max Dodson of EPA's Region 8 underscored the workshop's emphasis on a multimedia approach to understanding the problems and developing solutions attendant to this serious challenge to our modern society in his brief summary of the Denver Integrated Environmental Management Project.

Air, water, and soil are <u>interdependent</u> compartments of the environment, yet are often dealt with in an <u>independent</u> manner. The workshop stressed the need to consider all media in evaluating the scientific information available for any pollutants identified, and to take the multimedia aspects of environmental contamination into account for risk assessment and risk management. The workshop also recognized the challenge to protect the total environment, including but not exclusively public health, by making and administering legislation and regulations--often defined as single-medium, but just as importantly, analyzed and evaluated in terms of cross-media effects.

In his keynote talk, "Scoping the Problem," John Spengler of Harvard University introduced the dimensions of the multimedia problems that we encounter due to the varying amounts of pollutants in the environmental compartments

air, water, soil, and biota, both in time as well as in space. As an example, the distribution of pollutants between air and surface water was used. At several places, it is found that the amount of pollution deposition from the air surpasses the discharges of emission sources into the water. A further important intercompartmental topic that was touched upon was the relation of indoor versus outdoor pollution.

To illustrate the problems and the challenge in developing a multimedia risk assessment/risk management model, the workshop employed the case study method, using lead as a paradigm. David Weil of the U.S. Environmental Protection Agency summarized the outcome of the recent, detailed scientific assessment regarding the exposure and health effects of lead. He reported that lead is known to be a multimedia pollutant to which people are exposed through air, food, water, soil, and dust; it is estimated that each American has an average daily consumption of about 100 micrograms. Most of the atmospheric emissions (approximately 90%) in the past resulted from the combustion of leaded gasoline. However, that percentage is expected to drop significantly as EPA's Lead Phasedown in Gasoline program takes full effect in January, 1988. The EPA's assessment also concluded that the onset of health effects of concern can be observed at blood lead levels of 15-20 µg/dl in young children and at levels as low as 10-15 µg/dl in fetuses. Based upon evaluation of this data, the EPA is now considering revision of the National Ambient Air Quality Standard (NAAQS) for lead to protect as many young children as possible (e.g., 99.5%, as was done in setting the current NAAQS for lead) from exceeding a blood lead level of 15-20 µg/dl. Whether or not revising the standard to this level will be sufficient to protect fetuses from achieving blood lead levels of 10-15 µg/dl, given the relatively greater lead exposure of young children than pregnant women (and, hence, their fetuses), is under investigation at this time.

Next, a panel chaired by Magnus Piscator, Sweden, discussed some specific scientific investigations concerning lead. Paul Ciriello, USA, presented the results of a study to measure the lead content of soil in residential areas of Boston, Massachusetts. Actions have been taken to reduce the level of lead in ambient air, and the number of incidences of high-dose lead toxicity resulting from lead paint ingestion are decreasing. However, low-level toxicity among children remains a problem, primarily because of exposure to residual lead in soil and house dust. In certain densely populated areas, designated as elevated lead priority areas (ELPA's), one of every four children under the age of

six has shown a blood lead concentration beyond the acceptable range. Additional studies are under way to correlate causes and effects, and actions are being taken to remove the lead. These include vegetating bare soil as well as tilling, excavating, and filling.

Ian von Lindern, USA, summarized measured air and soil lead concentrations and blood lead levels of children living near the Bunker Hill Smelter in Northern Idaho between 1970 and 1983 (two years after the smelter had closed). He discussed the residual multimedia environmental problems and efforts to address these problems.

Gen Ohi, Japan, reported on investigations of possible lead poisoning in Tokyo in 1970. There were no documented cases of human lead poisoning. He was, however, able to correlate ambient lead levels with bioaccumulation of lead in pigeon tissues. This gives credence to the hypothesis that the pigeon can be an effective and sensitive (although magnified) biological indicator of such environmental contamination.

Erich Weber, FRG, presented two case studies of areas showing high lead concentrations. In Goslar, a lead and zinc processing complex has been in operation for hundreds of years. Since 1970, an extensive effort has been made to control emissions, including measuring ambient air and surface deposition. The second area, Braubach, has also experienced high lead deposition from a lead smelter, and agricultural use of the area is restricted. Efforts are under way to identify the sources and distribution of heavy metals and their effects on vegetation, employing a transport simulation model.

Sergio Facchetti, Italy, presented information on the isotopic lead experiment (ILE). In this large-scale field study, lead from an Australian mine was added to gasoline in the Italian Piedmont area. Investigators were able to follow the movement of the Australian lead through environmental pathways by analysis of its characteristic lead isotopic ratio. This enabled them to determine the relative contribution of local leaded gasoline to total airborne lead, to determine the contribution of gasoline lead to blood lead levels in urban and rural populations, and to follow the pathway of gasoline lead through environmental compartments more comprehensively. The data reported indicate that the contribution of gasoline lead to adult blood lead is about 23 percent in Turin and between 8 to 11.9 percent in the countryside. Lead in tap water and wine was higher in the countryside than in the city. Such factors as wine consumption may therefore importantly influence total blood levels.

In summing up all the presented results on lead pollution, the chair of the session, Magnus Piscator, concluded that a continuing decrease in lead emission into the air is demonstrated in all cases, but that total accumulation will still (slowly) increase and remedial measures towards soil and dust pollution should be taken.

Rolf Hartung provided the transition from the discussion of lead as a well-documented example of a multimedia pollutant to the session on methods for multimedia assessment. Compared to "data rich" pollutants such as lead and sulfur and nitrogen oxides, information for new hazardous pollutants often is lacking or incomplete. Establishing a dose-response curve for these compounds is therefore extremely uncertain. The complexity of the relationships is also indicated with the use of varying parameters: 1) dose rate, 2) duration of exposure, 3) intensity of response, 4) incidence of response, and 5) severity of response. Other uncertainties include the extrapolation to other species, from short- to long-term exposure, from high dose to low dose, and from one substance to a combination of substances. He recommended intensified efforts to state assumptions and uncertainties explicitly.

In the discussion following the presentation, it became clear that for carcinogenic substances the inherent uncertainties are smaller than for other toxic pollutants. The European approach in preparing and separating promoter from initiator carcinogens was recognized. Participants supported the statement that toxicological tests supplying accurate predictive results should be established before decisions regarding protection levels are made by policy-makers.

Magnus Piscator, chair of the session on multimedia assessment methods, began the presentations by discussing factors of importance for planning and interpretation of population surveys. The importance of the selection of specific chemical compounds as suitable exposure indicators was shown. Examples were given for arsenic, cadmium, and mercury. Depending on metabolic processes, speciation of chemical substances is of critical importance to the evaluation of survey data. For example, arsenic and mercury can appear in one form in an environmental medium, but differently in human urine.

The first method for multimedia assessment was presented by Franz Ellermann and Mathias Bock of the FRG. Ellermann described the effort involved

in collecting the data for development of the Environmental Atlas Berlin. The information was gathered over a period of 3 to 4 years. The greatest challenge was in establishing comparability, as the data has been developed originally for many different purposes using many different methods. The resulting graphic displays comprise 120 various maps of the Berlin area.

Mr. Bock described the computer-aided geographic information system (GIS) which used the atlas data to allow the identification of pollutant burdening and sensitive areas of the environment. Areas where these converge are a special concern. The aim is to allow planners and policymakers to model possible ecological consequences of a decision or set of decisions and display the results.

Margrit von Braun, USA, demonstrated pMAP©, a geographic information system (GIS) used as a multimedia tool for environmental analysis. The grid-based GIS includes analytic capabilities organized as a set of mathematical operations, which, like traditional algebra, may be combined to perform a variety of map analyses. This "map algebra" forms a structure for data base management, spatial statistics, and cartographic modeling. An example of soil contamination near a secondary lead smelter was discussed and demonstrated on a personal computer using a projection monitor. Hazard zone maps were combined with population and housing maps using GIS techniques to generate cross-tabulations such as numbers of persons and types of dwellings within each hazard zone. Including other factors, such as cost data for various cleanup scenarios, is the next step in producing a cost-benefit analysis for management decisions.

James Hatheway, USA, presented an overview of the EPA's National Enforcement Investigations Center (NEIC) multimedia compliance audit activities in support of pollution control agencies, which provided a background for a hands-on tour. NEIC staff were present to answer questions as workshop participants inspected an NEIC instrumented mobile compliance facility and the mobile lidar unit, used for smoke emission detection. Copies of the NEIC's most recent multimedia audit procedures were made available to participants.

Heinz Davidsohn of the FRG emphasized the recent attention to coherent and comprehensive environmental impact assessment in his description of the lower Elbe project. This study's objectives were to collect and analyze environmental data, including land use information, to provide a basis for integrating

environmental concerns into the land use planning process in the states of Bremen, Hamburg, Lower Saxony, and Schleswig-Holstein. The effort, under the general sponsorship of the Federal Environmental Agency, has resulted in specific recommendations designed to balance economic, social, and ecological interests. It is recognized that implementation will be real challenge to all levels of government, as no specific legislative mandate exists for consideration of environmental impact in land use planning decisions.

An experimental program to identify those chemical components of diesel exhaust particles having greatest toxic potential, in progress in Rome's Institute of Atmospheric Research, was described by Paolo Ciccioli, Italy. Working in conjunction with other Italian research facilities, investigators have collected and characterized exhaust particle samples from engines operated on the European Cycle for assay of mutagenic potential by the Ames test. Results indicate that Ames test revertent production was 10 times higher than for gasoline engine exhaust particles. It is suggested that 1-nitropyrene is the best chemical marker for evaluation of potential risk associated with diesel emission. The relative contribution of diesel exhaust particles to total 1-nitropyrene exposure is the subject of current research efforts; it is necessary to determine the extent to which the substance is dispersed in air, water, soil, plants, and subsequently, the food chain. Multimedia compartment models are required for comprehensive risk assessment.

Jean Parker, USA, discussed the U.S. EPA's efforts to improve the technical quality and consistency of its evaluation of scientific information. To achieve consensus on risk assessment issues, the EPA has established a Risk Assessment Council and Risk Assessment Forum. The former oversees development, review, and implementation of related policy. Development of a series of guidelines on risk assessment methodologies involves interdisciplinary participation by the 10 Forum members, selected for staggered 3-year terms by the Council. A series of risk assessment guidelines outlining the EPA's approach to evaluating the public health risks of environmental pollutants was published two weeks before the workshop, and copies were available for workshop participants.

Beverley Hanna Thorpe, Canada, presented a description of the Province of Ontario's procedure for developing multimedia environmental standards for two hazardous compounds: dioxins and dibenzofurans. The process includes a review of all existing data regarding toxicological effects in humans and an environmental assessment of sources, pathways, and effects. The process culminates in

an exposure assessment, review of abatement procedures, and proposed regulations to protect the health of Ontario's citizens and their environment.

The final methods session dealt with national strategies for managing multimedia contaminants. The panel session was chaired by Toni Schneider, The Netherlands, and included presentations by Christa Morawa, FRG; Alexander di Domenico, Italy; Yasushi Kodama, Japan; C. A. van der Heijden, The Netherlands; and Si Duk Lee, USA.

In the Federal Republic of Germany, due to the relevant legislation, environmental problems still have largely to be solved within the usual compartments of air, water, and soil. A number of activities have been started that aim at introducing cross-media ideas, such as a recently initiated soil protection program. Also, the ECE activity to reduce SO_2 and NO_x emissions by agreed-upon percentages takes into account effects on soil chemistry.

In Italy, a massive accidental release of dioxin at Seveso focused worldwide attention on the lack of information about health and environmental effects of dioxins and other persistent multimedia contaminants. The incident made it essential that the Italian government develop a comprehensive strategy for chemical risk management. The government responded with an array of legislation and regulations, and the EEC issued its own directives aimed at preventing similar occurrences elsewhere. The research response has clearly demonstrated that TCDD and other dioxins are widely occurring multimedia contaminants produced from a number of sources, whose relative importance varies according to time and place. Current research is aimed at understanding the health and environmental significance of exposure to highly complex mixtures of dioxins and similar compounds.

For Japan, a comparison was made between conditions existing in 1961 and in the early 1980's. Due to emission controls in the years after 1967 such as the Basic Law for Environmental Pollution Control and the Air Pollution Control Law, air pollution concentrations have been drastically reduced in the major cities and nationwide. Environmental pollutants are monitored on a continuous basis.

In The Netherlands, a multimedia assessment is made for each chemical compound to be regulated. In the beginning, only air quality criteria documents were prepared. Since 1985, multimedia assessment documents are prepared that cover all environmental media and also include food, drinking water, and occupational health factors. The documents contain summarized data on chemical

aspects, exposure assessments for various routes and media, toxicology, evaluation and risk assessment, and proposals for standards to protect human health. In recent years, documents have been developed for a number of compounds including acrylonitrile, ethylene oxide, vinyl chloride, chloroform, cadmium, 2,3,7,8 TCDD, and many others.

The U.S. government agencies are still structured to address single-purpose, problem-oriented programs. The single-medium statutes and policies of the past have worked well under the circumstances. That stage has been outgrown, however, and there is a need to take a more comprehensive look at environmental management in the future. Clean air and water are visible, and cross-media approaches are a more abstract concept; the holistic approach involves complex ideas. In addition to risk characterization, other aspects such as economic factors and control options have to be considered. Risk management of toxic chemicals has to be carried out with all with all the scientific uncertainties that exist. Regulatory priorities will be set, and economic impact of control options will be included. This approach allows selection of an appropriate regulatory strategy, based on the degree of risk reduction.

The final workshop session was co-chaired by Michael Berry and Christa Morawa. The major discussion in this session was a review of the issues that had been addressed throughout the workshop. The participants made a number of comments and suggestions with the goal of producing a set of proposed recommendations included in this report (see next page). Robert Bauman of the U.S. EPA led the discussion.

RECOMMENDATIONS

The following recommendations were the result of discussions during the final "Summary and Synthesis" session of the workshop, and represent participant consensus.

1. Often the imposition of control strategies causes or contributes to inadvertent or unsuspected environmental damage in other media. For example, we have seen that the inactivation and closing of a large lead smelter, while reducing the levels of airborne lead pollution due to smelter operations, nevertheless had a residual adverse effect on health because of the contamination of the soil. Blood lead levels remained high until the residual problem was addressed and dealt with.

It is therefore recommended that decision-makers, in assessing and managing the problems associated with hazardous air contaminants, remain cognizant of the multimedia implications to development of control strategies and strive to harmonize and coordinate methods to mitigate environmental harm across air, water, biota, and soil media.

2. Single-medium strategies, although easier to establish and implement from a point of view of institutional arrangement, legislative authority, and regulatory policy, often are ineffective in total protection of human health. For example, we found that while the strategy to reduce the lead content of gasoline has direct implications for the removal of airborne lead and therefore inhaled pollution, blood lead levels may also show correlation with ingested lead such as from lead contamination of food and beverages.

It is therefore recommended that decision-makers, in assessing and managing the problems associated with hazardous air contaminants, recognize, acknowledge, and understand the limitations of authorities restricted to a single medium. Effort should be expended to regulate and mitigate, from a multimedia perspective, the environmental insult.

3. Sizeable and largely undefined uncertainties are inherent aspects of risk assessment. While some of the uncertainty is due to the design of the

experimental protocol, the risk assessment process itself adds additional uncertainties. We acknowledge that it is not possible to express all the uncertainties in risk assessment in quantitative terms at this time; nevertheless, efforts should be made to state assumptions and uncertainties explicitly.

It is therefore recommended that NATO countries emphasize their commitment to support research in quantifying uncertainties in the risk assessment methodologies. Furthermore, member countries should be especially attentive to communicating risk to the public and to public acceptance of the risk assessment process and results derived therefrom.

4. The chemical complexity of some matrices is widely known. Analytical approaches, especially simulation models, for multimedia assessment, are not readily available.

It is therefore recommended that NATO member countries cooperate in the development of integrated simulation techniques which can assist in the multimedia risk assessment process. Multimedia models must be easy to use, yet flexible enough to cover a broad range of environmental problems. If at all possible, they should be designed in a modular fashion to provide the widest application. It is further recommended that a follow-on effort to the current NATO/CCMS pilot study be considered for developing and validating such models.

5. This workshop has once again stimulated the transfer of scientific knowledge--and scientific concerns and worries--among the air pollution professional community. However, there is an ever-present fear that we speak in a language which is largely unintelligible to the general public. Concern for environmental quality and the health and welfare of our modern society require continuous vigilance and constant emphasis and support. Education is paramount in the quest to attain our goals.

It is therefore recommended that NATO countries actively seek and support environmental education curricula for elementary school, secondary school, and college and university students. Furthermore, public outreach programs to increase the awareness of environmental problems and protection, to include scientific discussion as well as general approaches, should be pursued. In

the educational process, particular attention should be given to knowledge of the risk assessment process. Since too often our educational process tends to be compartmented, a broad-view, multinational program should be begun.

6. The 1986 workshop, with its focus on multimedia approaches to management of hazardous air contaminants, presented evidence, once again, to demonstrate how specialized and compartmentalized our organization for regulatory action has become. In many member countries, the control of hazardous materials is divided among several governmental bodies; functions of air pollution control, water pollution control, land disposal of hazardous materials, transportation and storage of hazardous substances, etc. are regulated by individual agencies of parts of the government. Whereas it was recognized that restructuring bureaucracies would be difficult, if not impossible, and may not even be desired, attitudes of separate and individual responsibilities must change.

It is therefore recommended that member countries strive during the next few years to develop close cooperation and coordination among governmental bodies in the scientific pursuit of environmental risk assessment. Two kinds of integration must be emphasized: integration across media and integration among policymakers and researchers. Member countries are encouraged to develop experimental multimedia programs.

7. Research on the environmental problems, as discussed above, must be sponsored and supported and the results must be rapidly and widely disseminated. Joint research, i.e., research sponsored by two or more countries or two or more governmental bureaus, is very difficult to accomplish. Common environmental problems, particularly transboundary problems in Europe, have led to jointly funded research. Sharing the resulting information has further encouraged joint sponsorship and funding. The 1986 workshop concluded that projects that demanded international research had a higher chance of successful joint sponsorship.

It is therefore recommended that member countries use the NATO/CCMS pilot study structure as a mechanism to recommend, select, and plan for joint research. Alternatively, informal contacts developed through the NATO/CCMS experience may be used to begin bilateral agreements. To foster this international

cooperation, research results must be shared among NATO countries. It is further recommended that results of investigations be published in standard NATO format (English and French languages) and that the NATO/CCMS structure be used as a clearinghouse for research results. Periodically, NATO/CCMS should publish a bibliography of available reports, and also a summary of international research in the planning stage.

III. PRESENTATION SUMMARIES

During the 2-1/2 day workshop, 22 presentations were made. They included a keynote address by John Spengler of Harvard University, who outlined the dimensions of the problem of multimedia, multiple exposure environmental contamination. The first session, "Defining the Challenge," opened with a summary of the scientific consensus on lead, by David E. Weil, U.S. Environmental Protection Agency. This was followed by five case studies in multimedia management of lead. Magnus Piscator of the Karolinska Institute in Sweden was chair of this session.

The case studies presented several approaches to assessing and managing specific instances of lead contamination. The speakers were Paul Ciriello, U.S. Environmental Protection Agency; Ian von Lindern, TerraGraphics; Gen Ohi, University of Tokyo; Erich Weber, Federal Republic of Germany; and Sergio Facchetti, Joint Research Center, Varese, Italy.

Following the examination of the challenges presented by environmental contamination with an element whose hazardous effects are well documented, Rolf Hartung of the University of Michigan presented an overview of the very difficult problems decision-makers and scientists face when they must deal with compounds where data on dose rates and dose-response are unclear. The uncertainty surrounding many such compounds presents an unusually strong challenge.

SESSION I: DEFINING THE CHALLENGE

Pollution Control at the Crossroads, John Spengler, Si Duk Lee, James Kawecki

Invariably, environmental regulations seem to come about in response to public health problems--often long-brewing problems that suddenly erupt into health crises. This has certainly been our experience in the United States, where historically we have responded to seemingly isolated events--polluted ground water, contaminated ambient air, hazardous wastes. But throughout this time, we have been learning from our mistakes. Today, we now realize that the environment, as described by Lee Thomas, "is a seamless web; that everything is connected to everything else." A typical individual is likely to encounter contaminants from water, food, and air, indoors and outdoors, in varying amounts during a day or throughout a lifetime. It is no secret that the concept of multiple exposures from various media has been more a backdrop to environmental regulations than a leading scene. But the process of assessing health effects from a diversity of exposures and the regulatory strategies to address these problems are extremely complex. To implement the concepts of environmental risk management, we need to know the absolute and relative hazards of contaminant exposures differentiated by location, media, populations, and durations. I would like to discuss with you today in this workshop on multimedia approaches to assess and manage environmental contaminants the dimensions of the problems, the progress we have made in addressing them, and the future directions.

The first area centers on human mobility--what are our typical activity patterns? Consider, for example: In several of our largest cities, a significant source of pollution is volatile organic compounds (VOC's). We may be exposed to them at the neighborhood cleaners and continue that exposure when we bring the cleaning into our homes, spray our pets for fleas, and store fuels, solvents, and gasoline for our lawnmowers. We also find the same VOC's in our water supplies and in our food. Federal regulations to control emissions of VOC's into ambient air can require pretreatment whereby a solid or liquid waste is formed. But improper disposal of that waste may further contaminate the air, the soil, and the groundwater.

Comparative studies have shown that we may average 20 to 22 hours a day inside a structure. We average about one hour a day in transit from structure to structure. Essentially, we are left with only an hour a day to spend outdoors, depending on the season. In some cases, this represents one hour less exposure to radon gas in our homes; in others it may represent less time outdoors exposed to elevated levels of ambient air ozone. So human exposure assessments must recognize the importance of multimedia sources--cross-media pollution. The task we face now is: How are we going to devise and manage this multimedia approach?

The rationale for an integrated pollutant management system is part of EPA's original charter. In July 1970, President Nixon's announcement on the reorganization of Federal environmental responsibilities stated the following:

> Despite its complexity, for pollution control purposes the environment must be perceived as a single integrated system. A single source may pollute the air with smoke and chemicals, the land with solid wastes, and a river or a lake with chemical or other wastes. Control of air pollution may produce more solid wastes, which would then pollute the land or water....A far more effective approach to pollution control would identify pollutants; trace them through the entire ecological system, observing and recording changes as they occur; determine the total exposure of man and his environment; examine interactions among forms of pollution; and identify where on the ecological chain interdiction would be most appropriate.

Current EPA policy requires that certain regulatory packages consider the risks of any cross-media transfer associated with a particular control practice. Additionally, EPA's integrated environmental management program is looking at a "cradle to grave" system of hazardous waste control in the New England region. EPA also plans to make cross-media pollution a priority in its annual planning process.

The next problem we face is implementation of multimedia regulations. Current environmental regulations are directed at the individual medium. The statutes do not require that the environment as a whole be considered in pollution control schemes. In part, we are legally locked into this "tunnel vision" approach. Obviously, the most direct route to removing these "legislative blinders" is to seek statutory changes. But as we all know, this is a complex and protracted effort. As scientists, environmental planners, managers, and administrators, we must refocus our research projects and dollars into

programs that address this issue. Expanded research funding will provide the information needed for establishing consistent and workable policies. Much remains to be done. Unglamorous as the work may be, we must press on, for together we can find new and better solutions to determining a whole-systems approach to environmental policy.

Summary of the Scientific Consensus on Lead, David E. Weil

The consensus referred to concerns current trends in scientific opinion with regard to the hazards posed by exposure to environmental lead. It was obtained by the Environmental Criteria and Assessment Office (ECAO) of the U.S. Environmental Protection Agency after revision of its 1977 document Air Quality Criteria for Lead, and is the final product of a rigorous review process conducted over the last 5 years that included extensive peer review, two rounds of public comment, and three public meetings held by the Clean Air Scientific Advisory Committee (CASAC) of EPA's Science Advisory Board. The conclusions presented here, therefore, represent a thorough consideration of the full spectrum of scientific opinion as reflected in the final version of the Lead Criteria Document (CD). The Lead CD and its Addendum are expected to be available in late October or early November.

Air quality data available through 1984 show that 90 percent of total atmospheric lead emissions resulted from combustion of leaded gasoline (the second highest contributor was lead smelting at 2.8 percent) (Figure 1). However, under EPA's current Lead Phasedown program, in which the allowable concentration of lead in leaded gasoline will decline by 90 percent to 0.1 g/gal, that figure can be expected to drop to around 45 to 50 percent, with the remainder coming from stationary industrial sources such as primary and secondary lead smelters and battery plants.

Lead is a multimedia pollutant to which people are exposed through air, food, water, soil, and dust. Current estimates of the baseline exposure in the U.S. for adult males, adult females, and two-year old children are approximately 51, 38, and 47 µg/day, respectively (Table 1). These values can be supplemented by additional exposure due to other factors such as living in an urban

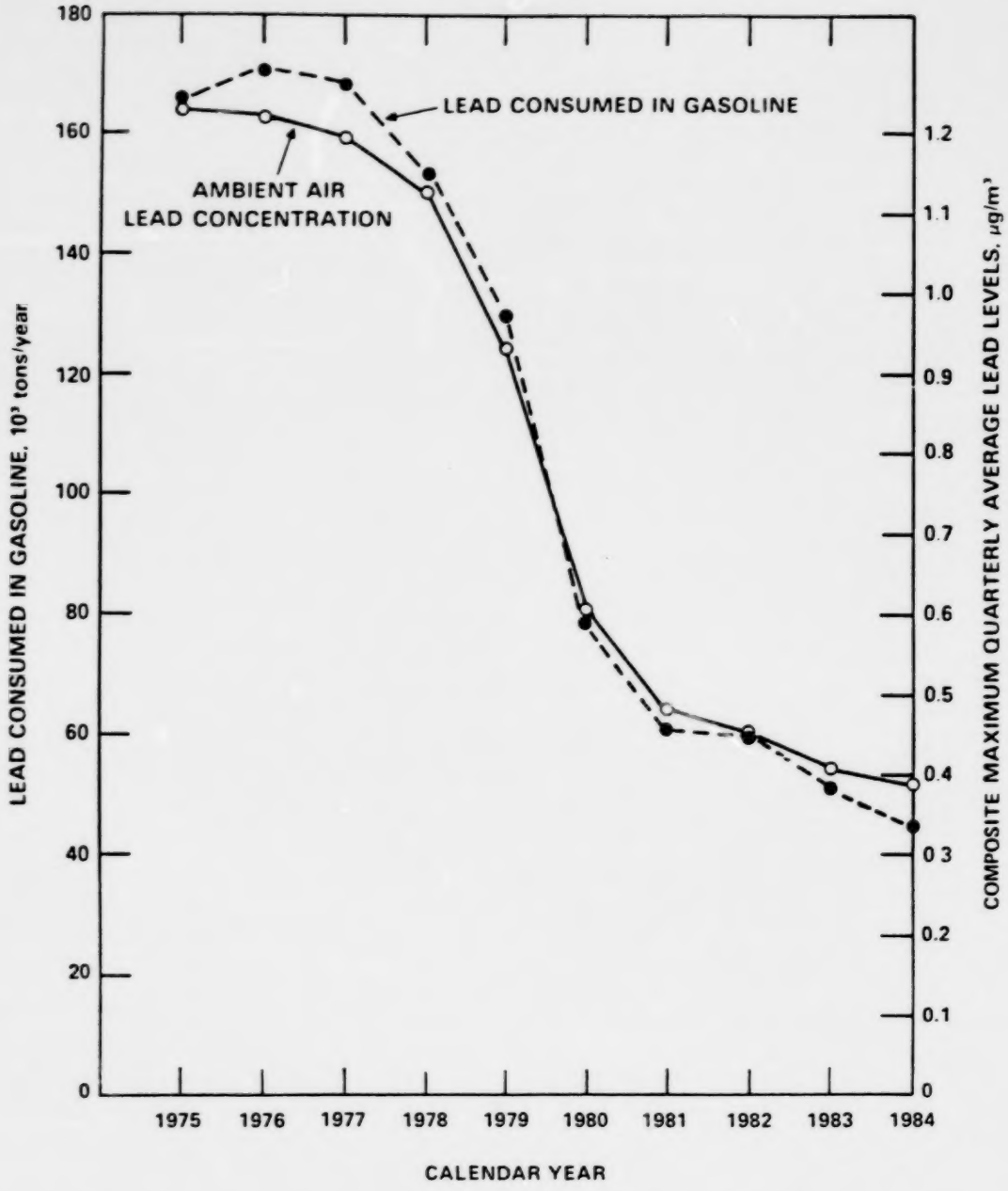


Figure 1. Lead consumed in gasoline and ambient lead concentrations, 1975–1984.

Source: U.S. Environmental Protection Agency (1985, 1986).

TABLE 1. SUMMARY OF POTENTIAL ADDITIVE EXPOSURES TO LEAD (μg/day)

Exposure	Total lead consumed	Atmospheric lead consumed	Other lead sources
Baseline exposure			
Child			
Inhaled air	0.5	0.5	-
Food, water & beverages	25.1	10.3	15.6
Dust	21.0	19.0	2.0
Total baseline	46.6	29.7	17.6
Additional exposure due to:			
Urban atmospheres	91	91	
Family gardens	48	12	36
Interior lead paint	110		110
Residence near smelter	880	880	
Secondary occupational	150		
Baseline exposure:			
Adult male			
Inhaled air	1.0	1.0	-
Food, water & beverages	45.2	20.3	34.4
Dust	4.5	2.9	1.6
Total baseline	50.7	24.2	36.0
Additional exposure due to:			
Urban atmospheres	28	28	
Family gardens	120	30	17
Interior lead paint	17		
Residence near smelter	100	100	
Occupational	1100	1100	
Secondary occupational	44		
Smoking	30	27	3
Wine consumption	100	?	?

area or in housing with lead plumbing, etc. As a consequence, it is currently agreed that the average daily consumption of lead is around 100 μg for each American. The fraction of blood lead that is directly attributable to lead in gasoline apparently can range from 10 percent up to 25 percent; the remainder comes from dust, water, food preparation, etc.

There is no real consensus on the exact nature of the blood lead/air lead relationship. ECAO used a "disaggregate" approach in the Lead CD to estimate the contribution of air lead separately from other sources, and identified a blood lead/air lead slope in the range of 1.64-1.92; the regulatory branch of EPA favors an "aggregate" approach, which considers air lead to be a surrogate for all exposure pathways, and has generated slopes in the range of 4-6. In either case, it is possible to calculate the total effect of given air lead concentrations on blood lead levels, and the two methods yield essentially similar results.

In general, the blood lead level at which adverse health effects are recognized as beginning to appear has fallen rather sharply since the previous Lead CD was published (1977) (Tables 2 and 3). At that time, the "maximum safe level" for pediatric exposure was defined as a blood lead level of 30 µg/dl. It is now felt that the onset of signs of detectable heme synthesis impairment, indications of interference in pyrimidine and Vitamin D metabolism, and alterations in central nervous system activity at blood lead levels starting around 15-20 µg/dl in children may be argued as becoming sufficiently of concern to warrant avoidance. There are also emerging data on the effects of perinatal exposure to low levels of lead on both physical and neurobehavioral development. This very new evidence appears to indicate that fetal exposure to blood lead levels as low as 10 to 15 µg/dl, or even lower, can have undesirable effects on infant mental development, length of gestation, and possibly such other aspects of growth and development as birth weight and head circumference. However, the physiological mechanisms whereby lead may exert such influence remain largely speculative at this time.

Furthermore, recent data on the nature of the relationship between blood pressure and blood lead ranging from levels ≤30-40 µg/dl down to possibly as low as 7 µg/dl have led EPA to identify middle-aged white males (40-59 years) as yet another subpopulation which is potentially at risk; this is in addition to the other, more traditionally accepted groups at risk, i.e., preschool-aged children (≤6 years) and pregnant women (due to the risk to the fetus). Table 4 gives an estimate of the total number of individuals in each of these population segments.

Consideration of all of the data reviewed in the Lead CD has led EPA staff to the preliminary conclusion that the maximum acceptable blood lead level for a young child should not exceed 15-20 µg/dl, while that of a fetus should not

TABLE 2. SUMMARY OF LOWEST OBSERVED EFFECT LEVELS FOR KEY LEAD-INDUCED HEALTH EFFECTS IN ADULTS

Lowest observed effect level (PbB)*	Heme synthesis and hematological effects	Neurological effects	Effects on the kidney	Reproductive function effects	Cardiovascular effects
100-120 µg/dl		Encephalopathic signs	Chronic nephropathy		
80 µg/dl	Frank anemia				
60 µg/dl				Female reproductive effects	
50 µg/dl	Reduced hemoglobin production	Overt subencephalopathic neurological symptoms		Altered testicular function	
40 µg/dl	Increased urinary ALA and elevated coproporphyrins	Peripheral nerve dysfunction (slowed nerve conduction)			
30 µg/dl					Elevated blood pressure (White males,) aged 40-59
25-30 µg/dl	Erythrocyte protoporphyrin (EP) elevation in males				
15-20 µg/dl	Erythrocyte protoporphyrin (EP) elevation in females				
<10 µg/dl	ALA-D inhibition				?

TABLE 3. SUMMARY OF LOWEST OBSERVED EFFECT LEVELS FOR KEY LEAD-INDUCED HEALTH EFFECTS IN CHILDREN

Lowest observed effect level (PbB)[a]	Heme synthesis and hematological effects	Neurological effects	Renal system effects	Gastrointestinal effects
80-100 µg/dl		Encephalopathic signs and symptoms	Chronic nephropathy (aminoaciduria, etc.)	Colic, other overt gastrointestinal symptoms
70 µg/dl	Frank anemia			↓
60 µg/dl		Peripheral neuropathies		
50 µg/dl		↓ ?		
40 µg/dl	Reduced hemoglobin synthesis	Peripheral nerve dysfunction (slowed NCV's)		
	Elevated coproporphyria	CNS cognitive effects (IQ deficits, etc.)		
	Increased urinary ALA	↓		
30 µg/dl		?	Vitamin D metabolism interference	
15 µg/dl	Erythrocyte protoporphyin elevation	Altered CNS electrophysiological responses	↓	
10 µg/dl	ALA-D inhibition	↓	?	
	Py-5-N activity inhibition[b]	?		
	↓			
	?			

TABLE 4. PROVISIONAL ESTIMATE OF THE NUMBER OF INDIVIDUALS IN URBAN AND RURAL POPULATION SEGMENTS AT GREATEST POTENTIAL RISK TO LEAD EXPOSURE

Population segment	Actual age, (yr)	Total Number in U.S. population (1984)	Urban population*
Preschool children	0-4	18,453,000	11,256,000
	5	3,576,000	2,181,000
	6	3,374,000	2,058,000
Total		25,403,000	15,495,000
Women of child-bearing age	15-19	9,019,000	5,502,000
	20-24	10,481,000	6,393,000
	25-29	10,869,000	6,630,000
	30-34	10,014,000	6,109,000
	35-39	9,040,000	5,514,000
	40-44	7,179,000	4,379,000
Total		56,602,000	34,527,000
White males	40-44	6,064,000	3,699,000
	45-49	4,960,000	3,026,000
	50-54	4,600,000	2,806,000
	55-59	4,760,000	2,904,000
Total		20,384,000	12,435,000

*An urban/total ratio of 0.61 was used for all age groups. "Urban" includes central city and urban fringe populations (U.S. Bureau of the Census, 1983).

Source: U.S. Bureau of the Census (1984), Table 6.

exceed 10-15 μg/dl. Given the relatively greater lead exposure of young children than pregnant women (and, hence, their fetuses), the Office of Air Quality, Planning, and Standards (OAQPS) will probably recommend that the National Ambient Air Quality Standard (NAAQS) for lead be revised to protect as many young children as possible (e.g., 99.5%, as was done in setting the current NAAQS for lead) from exceeding a blood lead level of 15-20 μg/dl. Whether or not revising the standard to this level would offer adequate protection to fetuses as well, due to the relative differences in total lead exposure between young children and pregnant women, is under investigation at this time.

Preliminary calculations indicate that protecting 99.5% of children from exceeding a blood lead level of 15-20 μg/dl would result in a mean population blood lead level in the range of 6 to 8 μg/dl. Depending on which of many

mathematical assumptions one chooses to use, the achievement of a mean population blood lead level in this range might require reducing the current lead NAAQS to a level below 1.5 $\mu g/m^3$; the precise figure will depend on several factors, including the averaging time, monitoring requirements, and mathematical form of the standard, as well as the estimated contribution of non-atmospheric sources of lead to total exposure. It is expected that OAQPS will circulate its new conclusions and recommendations regarding revision of the lead NAAQS for public review in a revised "Staff Paper" sometime in late 1987.

Lead in Soil Case Study: Boston, Massachusetts, Paul Ciriello

Childhood exposure to elevated levels of lead in soil and house dust is contributing to a growing population of low-level lead poisoned children in Boston, Massachusetts and other cities across the country. In fact, it is estimated that low-level poisoning now accounts for 90 percent of all lead poisoning cases. While toxicity from chronic exposure is less dramatic and the effects less obvious than high-level lead toxicity associated with acute exposure, the health implications are nonetheless very significant.

The Centers for Disease Control (CDC) recognized the presence of adverse health impacts at low-level blood lead concentrations and reacted by lowering its level of concern from 30 µg/dl to 25 µg/dl. This decision, made in January 1985, is the latest in a series of reductions running back into the 1970's. In 1973, for example, CDC lowered the level of concern from 50 µg/dl to 30 µg/dl. This "ratcheting down" trend is stimulated by evidence that children are suffering adverse health effects that influence their physical and intellectual development. And, mounting evidence on health effects at lower levels of exposure may lead to further reductions in the years ahead.

The Environmental Protection Agency recognized the public health implications of human exposure to lead in the environment and reacted by phasing out lead in gasoline and adjusting pH in public water systems. The acceptable blood lead levels used in assessing the health effects associated with these decisions are both below 25 µg/dl, indicating the need to eliminate exposures that pose threats at even lower levels.

While it is indisputable that these actions will result in lower blood lead levels in the general public, they will be ineffective in reducing the blood lead levels of children exposed to other sources, like lead in soil and house dust. Past regulatory actions were not geared to addressing residual soil contamination created by decades of uncontrolled vehicle emissions and lead paint deposition from the deteriorating exterior surfaces of homes. As a result, lead in soil is likely to grow in relative significance as a source of exposure for children and adults.

The problem in Boston is not protecting the general population from exposure to lead in ambient air nor is it one of reducing an already shrinking number of incidences of high dose lead toxicity associated with lead paint ingestion. Rather, the problem is one of pervasive low level toxicity among young children that can result from exposure to extremely high levels of lead in soil and house dust in some densely settled, urban neighborhoods (Table 1).

TABLE 1. PROFILE OF ELEVATED LEAD PRIORITY AREAS IN BOSTON, MASSACHUSETTS

	Boston	ELPAs
Number of Children Poisoned 1980-1985	3,451	982
Percent of Children Screened	.02	.34
Median Income [$/Year]	16,062	11,515
Families Below Poverty	16.7	29.9
Percent of Homes Built - 1950	85	78
Percent Units Renter-occupied	61	74
Median Rent [$/Month]	206	149
Average Soil Lead Levels	700	1,850

Source: City of Boston, Office of Environmental Affairs.

The population at greatest risk is children between the ages of nine months and six years. Poor children living in densely settled urban areas with poorly maintained homes are likely to be most imperiled. However, the children of more affluent urban homesteaders are at similar risk, especially during and after home renovation.

In some Boston residential neighborhoods, backyard soil lead levels average 2,000 parts per million, an order of magnitude higher than the level that the Centers for Disease Control believes is "responsible for blood lead levels in children increasing above background levels." The house dust levels in these homes are correspondingly higher, with average levels in the 3,000 ppm range.

Children living in these areas have an extraordinary chance of suffering from lead poisoning (Table 2). In fact, in the Boston hot spots, one out of every four children under the age of six has been lead poisoned, i.e., total blood lead greater than 30 µg/dl, in the past 5 years. Despite interior paint deleading, in many cases, poisonings continue. We also have evidence that indicates that seasonal changes affect the rate of lead poisoning.

TABLE 2. CHILDHOOD LEAD SCREENING IN BOSTON, MASSACHUSETTS 1980-1985

Year	Children Screened In City	Children Poisoned In City	Percent Children poisoned	Children Screened In ELPAs[1]	Children Poisoned In ELPAs[2]	Percent Children Poisoned
1980	20,243	898	.04	560	296	.53
1981	20,414	533	.03	900	290	.32
1982	22,245	473	.02	767	174	.23
1983	25,526	556	.02	628	222	.35
1984	25,592	496	.02	N/A	N/A	
1985	29,408	495	.02	N/A	N/A	
Total	143,428	3451	.02	2,855	982	.34

[1]Poisoned child determined by using 30 µg/dl, old CDC guidelines. The number of children who would screen positive using 25 µg/dl, the new CDC guidelines, may be 50 percent greater.

[2]Total in ELPA census tract.

Source: City of Boston, Office of Environmental Affairs, Lead Screening Program.

Public policy responses to this urban environmental public health threat have been slow to emerge. Most public officials are deeply concerned about the magnitude of the problem and their ability to respond within current budgetary

and legislative limitations. Yet, the long-term human health effects of childhood exposure to elevated levels of lead in soil present us with a most pressing public policy challenge that must be addressed. The decisions that we make in managing the Boston lead in soil case will help expand public awareness of the problem and help set the pace for action in other parts of the country.

Excess Blood Lead Absorption and Environmental Exposures in the Vicinity of the Bunker Hill Smelter in Northern Idaho: An Historical Perspective, Ian von Lindern

This presentation summarizes nearly 13 years of effort to assess and mitigate excess blood lead absorption and environmental metals exposures to children living in the Silver Valley of northern Idaho. Excessive blood absorption in the population surrounding the Bunker Hill primary lead smelter near Kellogg, Idaho first came to public attention in 1974. Studies conducted following an episode of extremely high emissions showed that 98 percent of the children living within one mile, and more than 100 children in the general area of the smelting complex, had blood lead levels exceeding 10 µg/dl. Forty-one children had levels exceeding 80 µg/dl and levels as high as 163 µg/dl lead with F.E.P. levels exceeding 1000 were also observed. Table 1 shows typical exposure levels noted during 1974. Several corrective actions were undertaken in the next year to reduce the level of absorption. Those included emission reductions at the complex, replacement of contaminated soils, relocation of families, home-health

TABLE 1. TYPICAL LEAD EXPOSURES BY DISTANCE FROM SMELTER 1974

Distance	Air ($\mu g/m^3$)	Soil (ppm)	Dust (ppm)
0-1 mile	20.0	7,500	12,000
1-2½ miles	15.0	3,300	10,000
2½-5 miles	8.0	1,000	2,500
5-8 miles	4.0	1,200	3,000
>8 miles	2.0	2,100	3,200
Control	1.0	200	500

intervention programs, community greening and others. These efforts resulted in dramatic decreases in community lead absorption; but levels for many individuals remained above recommended limits.

The State Health Department continued to monitor both blood and environmental levels of lead in the community throughout the remainder of the decade. Both continued to exceed Federal criteria and a limited health intervention program addressed extreme absorption cases. Figures 1 and 2 show respectively historical airborne and blood lead levels from 1974 through 1983. In late 1981 the smelter closed and airborne lead levels dropped almost immediately to concentrations below Federal health standards. Blood lead levels in area children followed a similar pattern. In August of 1983 a comprehensive study of blood lead and environmental exposure levels was undertaken. That study indicated that nearly one-quarter of the preschool children residing within one mile of the complex continued to exhibit blood lead levels in excess of 25 µg/dl. Several of those children had been born since the smelter closed. Residual lead contamination in local soils and house dusts and fugitive dusts generated from roadsides and barren soil areas were identified as the principal sources of excess lead to children in the local environment. Summary blood lead and environmental exposure levels are shown in Tables 2 and 3 respectively.

TABLE 2. 1983 BLOOD LEAD ABSORPTION LEVELS

Distance	Mean Blood Pb µg/dl	Percent Toxicity
0-1 mile	21	25%
1-2½ miles	17	9%
2½-5 miles	12	2%

TABLE 3. COMPARISON OF 1983 AND 1974 LEAD EXPOSURE LEVELS

	1974	1983
0-1 Mile		
Air	20.0	.2
Soil	7500	5500
Dust	12,000	4100

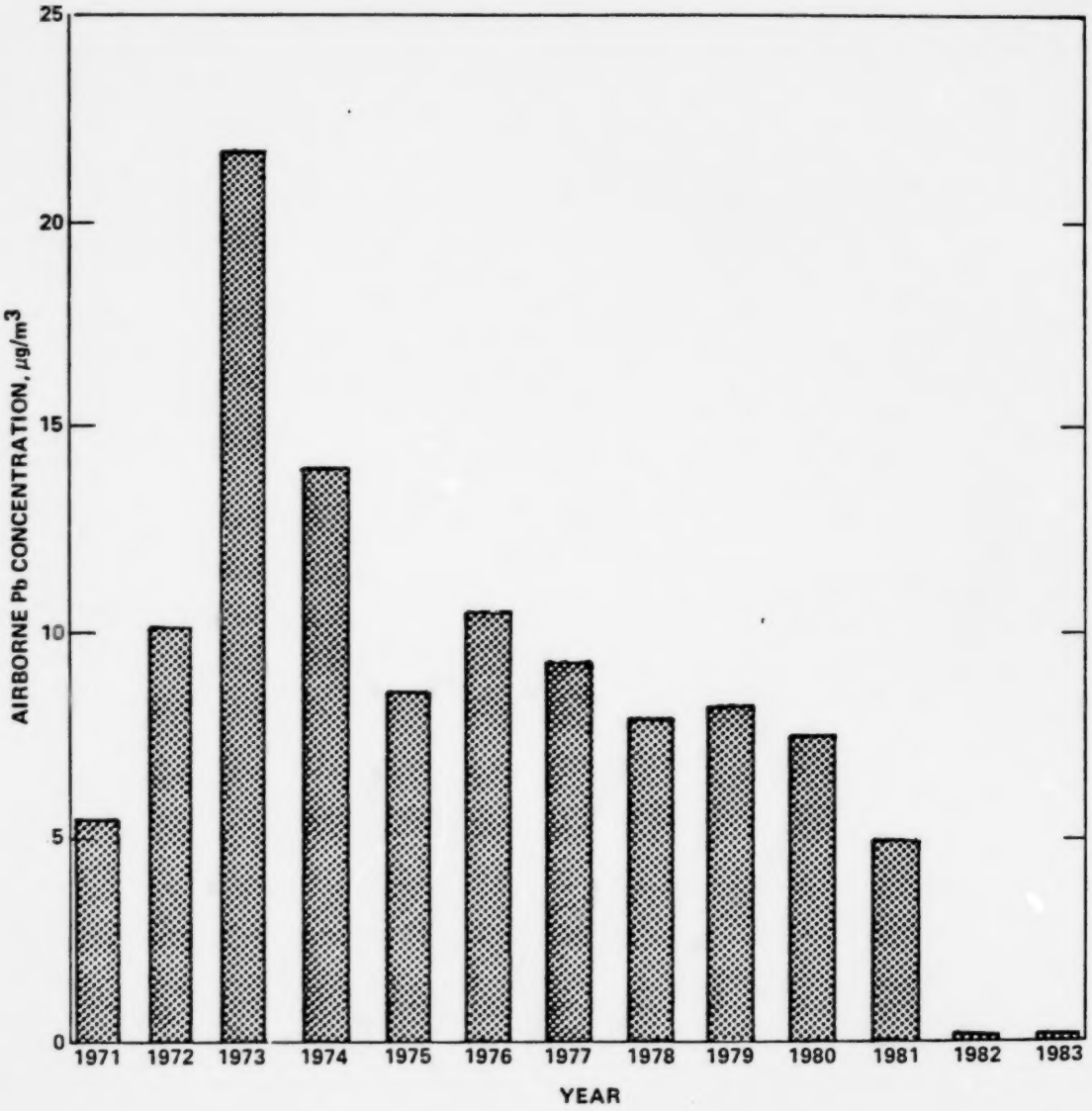


Figure 1. Airborne lead levels from 1971 through 1983 in residential area near the smelter complex.

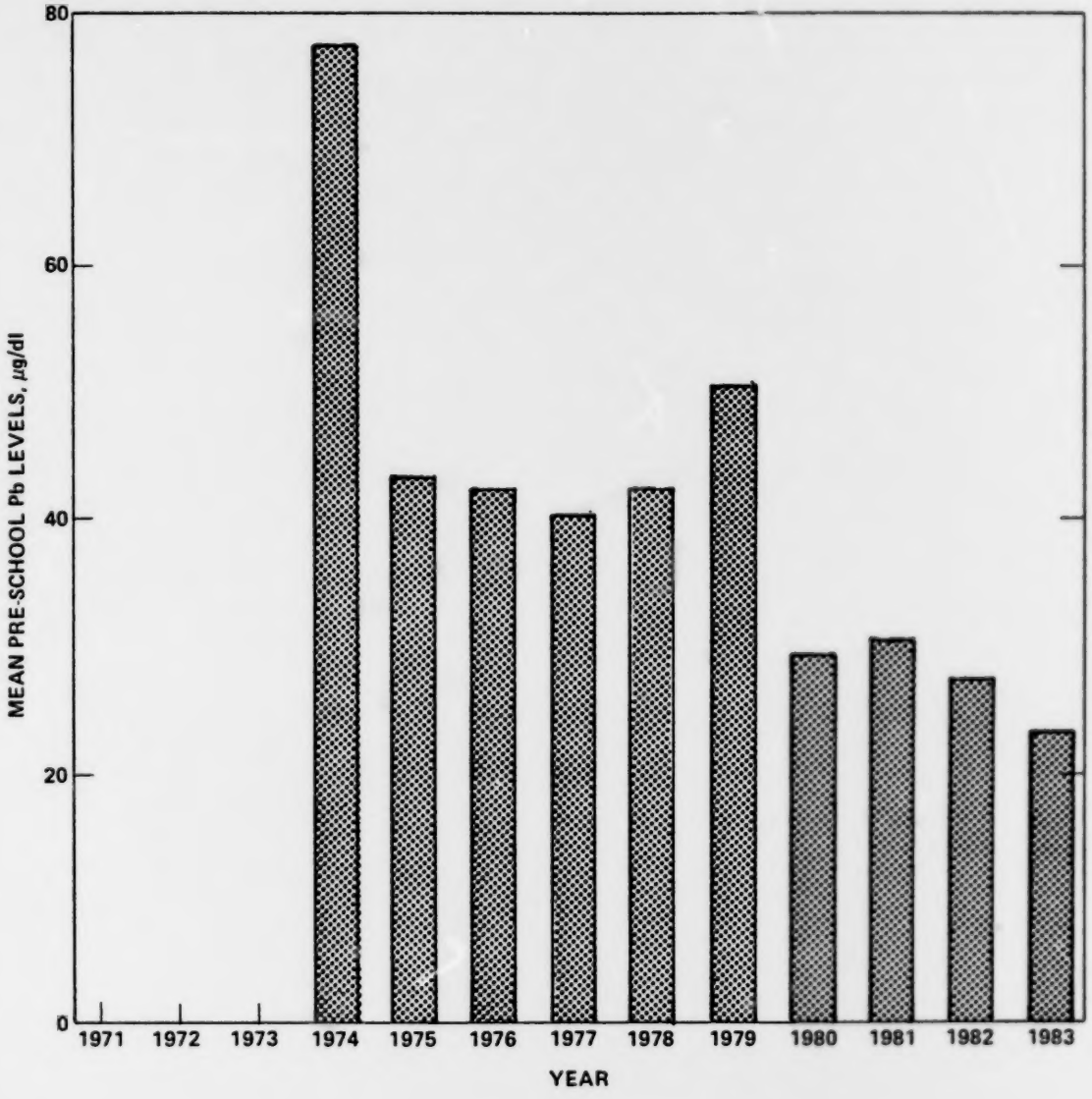


Figure 2. Mean pre-school blood lead for children living in residential area near the smelter complex.

In late 1984, a Federal "Superfund" effort was instituted in this area to comprehensively address environmental metals exposures. That project has the ultimate goal of "cleaning up" and permanently mitigating excessive exposures. However, the 21 square mile area designated for the Bunker Hill Remedial Investigation and Feasibility Study (RI/FS) represents one of the nation's largest and most complex hazardous waste sites. The area is located in a steep mountain valley drainage in northern Idaho and has been the center of one of the world's most active and productive lead, zinc, and silver industries for over a century. The current site boundaries encompass four incorporated cities; an affected population of more than 5,000 persons; a large river floodplain; an immense, largely dormant industrial facility including a major mine and mill works, primary lead smelter, primary zinc smelter, ammonium phosphate fertilizer plant, over 160 acres of impounded tailings, and several hundred acres of contaminated soils and waste piles.

In order to carry out this project effectively, protect the public health in the interim, and achieve maximum benefit to the local community, a comprehensive management strategy was developed. An aggressive lead absorption monitoring and follow-up program has been adopted. In the 2 years since its inception, excess absorption among preschool children has dropped from nearly 25 percent to less than 2 percent in the most severe exposure area. Interim remedial programs have been undertaken to reduce community exposures at playgrounds, parks, and roadsides through removal and replacement of contaminated soils on public properties. In the next year, additional interim remedial measures will address contaminated residential yard soils and major windblown dust sources. Meanwhile, planning studies for the eventual cleanup of the smelting properties and mitigation of environmental and natural resource damage in the area will proceed.

Assessment and Management of Lead Burden by Air Pollution: Two Case Studies, Erich Weber

Lead is one of the widespread heavy metals in the environment. The reason for this is the use of lead by man from ancient times till now, especially since the industrial revolution. The most crucial problems associated with lead in the environment are its tendency to accumulate in certain compartments of the environment, its persistence, and its toxicity.

With regard to the Federal Republic of Germany, the transport and distribution of lead from stationary and mobile sources is mainly via air and via deposition from the air to other environmental media.

In the FRG, lead concentration in ambient air is monitored routinely at 91 stations, lead deposition at 1,772 stations. Lead concentrations in ambient air are found to be around 0.1 $\mu g/m^3$ in remote areas and 1 $\mu g/m^3$ in polluted areas. The standard for lead in ambient air is 2.0 $\mu g/m^3$.

In remote areas, total lead deposition is in the order of 40 $\mu g/(m^2 d)$; however, in certain cases it may go up to 160 $\mu g/(m^2 d)$. The standard of lead deposition is 250 $\mu g/(m^2 d)$. In the vicinity of certain lead smelters, levels exceeding the standards are still observed.

Two case studies are presented below.

1) Sanitation of a lead/zinc-processing complex in the Harz region near Goslar. (Oker/Harlingerode).

In 1970, an extensive sanitation program was initiated. From 1970 to 1982, about 50 Mil DM have been spent for emission control measures, e.g.:

- shut-down of plants with high emission rates;
- installation of high efficiency scrubbers;
- cleaning of exhaust gases of special processes;
- switching to cleaner production of secondary zinc products;
- building of shelters to store and transload heavy metal containing materials;
- investigation of dust emissions of all sources;

- ambient air concentrations measurements at 20 sites, deposition fluxes at 40 sites within an area of 2.5 x 3 km^3;
- deposition to plant surfaces measurements with standardized grass cultures at 16 sites.

Dispersion and deposition in this complex terrain are simulated by a lagrange particle simulation model. The model requires, among others, the emission data from the aforementioned measuring campaigns and the three-dimensional fields of the meteorological variables which are measured at 4 meteorological towers of 10-20 m height and by a doppler sodar.

At present, model verification is performed. Through this modeling activity, it is intended to establish a tool applicable to other complex terrain situations.

To control the efficiency of these measures, monitoring programs initiated within a 42 km^2 assessment are:

- Concentration of lead and cadmium is measured in ambient air, soil, fruits and vegetables, cereals and feed stuff.
- Blood lead content of 288 people (248 children) has been investigated. In addition, urine and hairs have been analysed. Further investigations included 1,300 people.
- Efforts to improve polluted soils by liming, ion exchangers, deep soil digging, and application of gypsum were initiated.

The above sanitation program has proven to be successful. This is demonstrated, for example, by the decrease of lead deposition measured in the assessment area from 1981 to 1984. An average decrease of 51 percent in lead deposition was found. Nevertheless, in certain areas the standard is still exceeded.

2) Heavy metal balance in the vicinity of a lead smelter near Koblenz (Braubach) and investigation of accumulation effects.

Many years ago, primary processing of lead ores was stopped; nowadays lead-containing scrap metals are processed. The waste gases of the furnaces are collected, filtered, and released into the atmosphere via a stack at the

top of a hill 200 m above the valley bottom. Despite this measure, emissions of equal order of magnitude are released within the valley itself due to emissions through the windows of the shelters, dust raised by traffic, and wind-blown dust from piles.

The inhabitants living there are strongly affected which has been stated by lead-blood investigations. Agricultural use of the area is restricted; cultivation of fruits and of wine is forbidden.

In order to clarify the lead burden in the vicinity and to support emission control measures, the following problems are investigated:

- Which amount of lead is emitted by which sources?
- Which ambient air concentrations and deposition fluxes are occurring?
- What happens with the deposited lead-containing dust?

A research program, sponsored by the Federal Environmental Agency, is devoted to answering the above questions.

Lead Pollution in Tokyo Reflected in the Pigeon and Man, Gen Ohi

In the late 1960's, unrestricted proliferation of automobiles culminated in greatly elevated lead concentrations in the ambient atmosphere in the metropolitan Tokyo area usually ranging 2 to 3 μg Pb/m^3. In the Spring of 1970, a claim was made that residents in the neighborhood of an intersection with heavy traffic in central Tokyo had developed lead poisoning by breathing ambient air polluted with lead. The occurrence of the lead poisoning was attributed to three factors: 1) lead being discharged from automobiles, 2) heavy traffic congestion, and 3) geographic condition blocking the movement of air. In response to the situation, the amount of tetraethyl lead, an additive to regular gasoline, was reduced from 3 to 1.1 ml/gallon in summer 1970 and corresponding falls in atmospheric lead concentration were noted in the Tokyo area. More than 2,000 residents were screened for lead poisoning in 1970 in various parts in the

metropolitan Tokyo area but not a single case meeting the criteria for lead intoxication was uncovered. The diagnosis of lead poisoning on the patients purported to be intoxicated was never confirmed.

We studied the lead pollution in the metropolitan Tokyo area using a sensitive biological indicator, the feral pigeon Columba livia var. The study demonstrated that there were marked regional differences in the intensity of lead pollution among the areas of heavy and light traffic (Table 1). We assumed that this discrepancy had arisen from factors that might greatly increase lead intake by the pigeon, such as their very limited range of daily activities, the minute ventilation (per unit weight) many times greater than that of man, and their habit of ingesting sands thickly coated with lead for gizzard gravels.

TABLE 1. LEAD CONTENT IN VARIOUS TISSUES AND ALA-D ACTIVITY, SHOWING INFLUENCE OF REGIONAL LEAD CONCENTRATIONS

Locations	Remarks	Lead content (μg/g)[1] Femur#	Kidney[2]	Blood Pb (μg/dl)	ALA-D activity (μmol PBG/ RBC/h)
Central Tokyo					
A. Asakusa	Crowded temple, 100 m away from two main streets	31.6±16.0[3] n = 35	2.8±2.4[3] n = 37	33.0±20.4[3] n = 18	0.1[illegible]±0.12[3] n = 38
B. Shibuya	Bus terminal surrounded by main streets	24.8±20.9 n = 28	3.4±3.5 n = 23	32.8±13.8 n = 15	0.16±0.18 n = 20
C. Gokokuji	Quiet temple, 50 m away from a main street	16.5±23.3 n = 47	1.7±2.8 n = 23	15.1±12.2 n = 15	0.18±0.09 n = 20
Suburban Tokyo					
D. Tama	Quiet zoo in rural area	3.2±6.9 n = 47	0.8±1.1 n = 47	5.4±2.3 n = 20	0.58±0.18 n = 45
E. Nakatomi	Farm house in rural area	2.0±3.0 n = 13	0.4±0.3 n = 13	2.9±3.0 n = 38	0.43±0.17 n = 35

[1]Measured only with those which were sacrificed.

[2]Expressed on a wet basis.

[3]Mean ± S.D.

However, as far as human beings were concerned we failed to find any evidence suggesting the presence of lead poisoning among shoe shiners who had been at work sitting beside the road with perhaps the heaviest traffic in Tokyo. They were in the location where they would probably inhale fairly large respirable lead particles in addition to smaller particles floating in the ambient air. Some of them had been practicing shoe-shining for more than a decade.

In February 1975, the Japanese government totally banned the addition of tetraethyl lead to regular gasoline. Since in 1975 and 1976 we observed that the pigeons in downtown Tokyo had still maintained the high levels of blood lead, we have continued our periodic monitoring of the feral pigeon for lead pollution. Subsequently, we observed the pigeon reflected amelioration of lead pollution with a few years of lag time after the improvement of the atmospheric lead concentration was first noted (Figure 1).

A Case Study in Multimedia Management of Lead: Piedmont, Italy,

Sergio Facchetti

The Isotopic Lead Experiment (ILE), a large scale field study using lead from the Australian Broken Hill Mine as an antiknock compound added to petrol, has been subdivided into the following periods:

Phase "0" - background definition: July 1974 - July 1975

Phase "1" - transition period; about 60 percent of Australian lead in petrols: August 1975 - April 1977

Phase "2" - use of about 90 percent of Australian lead as additive in petrols: May 1977 - December 1979

Phase "3" - gradual switch-back to the initial lead in petrols: January 1980 - January 1985

The objectives of the ILE project were:

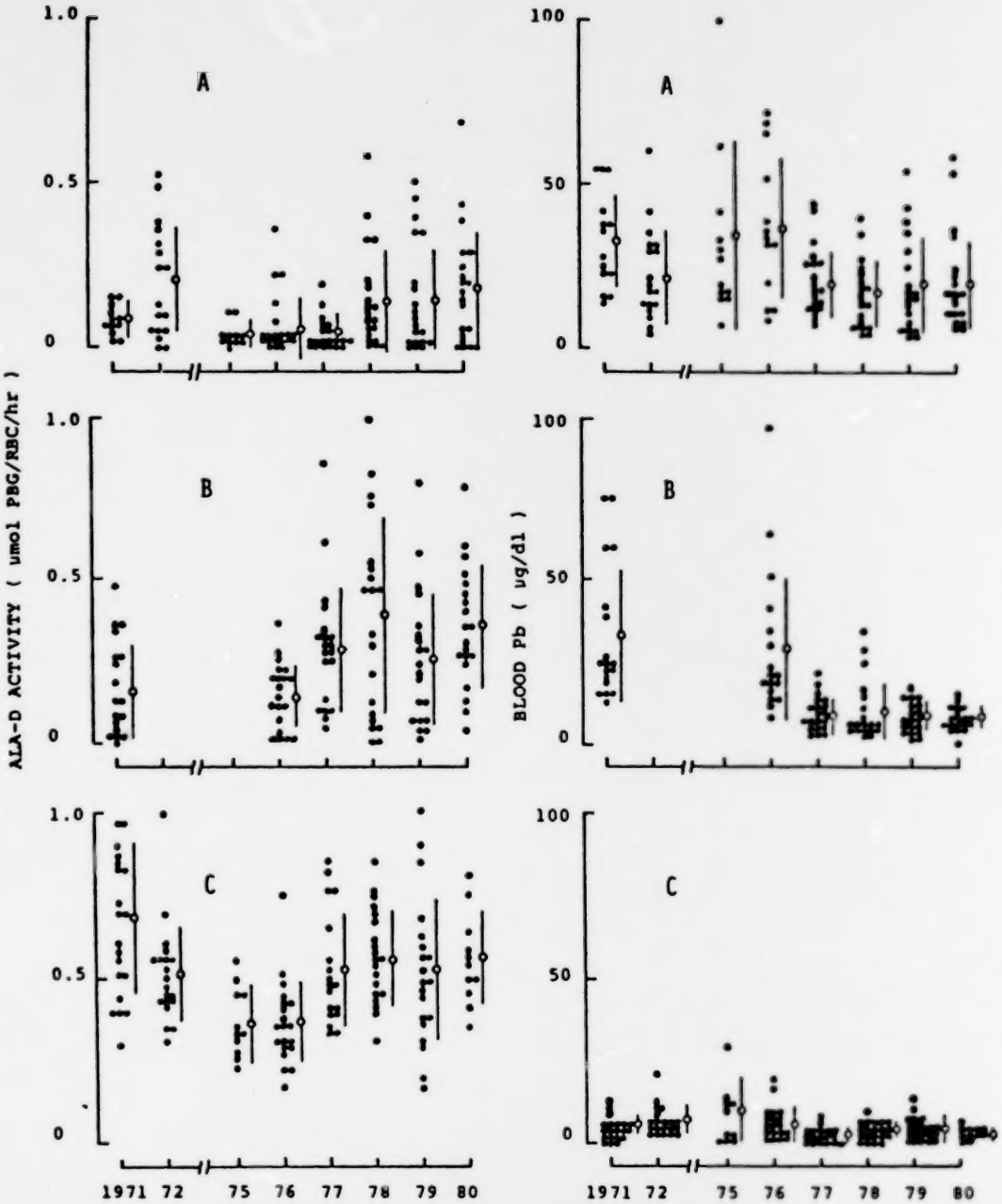


Figure 1. Annual transition of blood lead levels and erythrocytic ALA-D activities of the feral pigeons in downtown and suburban Tokyo. (A): A bus terminal surrounded by main streets and a highway; (B): a crowded temple, ca. 100 m away from two main streets; (C): a quiet zoo in the suburb of Tokyo. Monitoring of the pigeons was not done in 1973 and 1974 because of the belief that lead pollution had become a dead issue with the enforcement of the regulation and with the rapid fall in the atmospheric concentration of lead in Tokyo metropolitan area.

- to determine the contribution of petrol lead to total airborne lead in urban and rural areas;
- to determine the contribution of petrol lead to blood lead level in various population groups;
- to follow more generally the pathway of petrol lead through environmental compartments.

We report an updated evaluation of the results so far obtained in relation to the first two above-listed objectives. Such an evaluation is based only on the variation of the Pb-206/Pb-207 isotopic ratio (Figure 1). It should be noted that the determination of lead concentrations in airborne particulates and in blood are not required, provided that exposure remains constant.

The values obtained could be considered high or low according to the different aspects which are considered. Therefore, we list the conditions which may influence our findings.

- Conditions which contribute to high values:
  - The lead concentration in petrol is equal to 0.63 g/l;
  - The test site is characterized by a low intensity atmospheric circulation during about 60 percent of the time. Calm periods are characterized by strong inversions and multiple stratification which impede vertical mixing;
  - The city of Turin had the highest car/inhabitants ratio in Europe (0.4 in 1977) and its traffic volume corresponded to 5.6 percent that of the whole in Italy.

- Conditions which contribute to low values:
  - Due to the remodeling of bones, the isotopic ratio of blood lead and of the accessible bone lead are likely to converge continuously in an asymptotic manner. Therefore, this equilibrium was not reached by the end of Australian lead distribution (December 1979 - January 1980).

Results

The accuracy of isotopic ratio analysis was within 0.1 percent, guaranteed by a continuous internal and external quality assurance program.

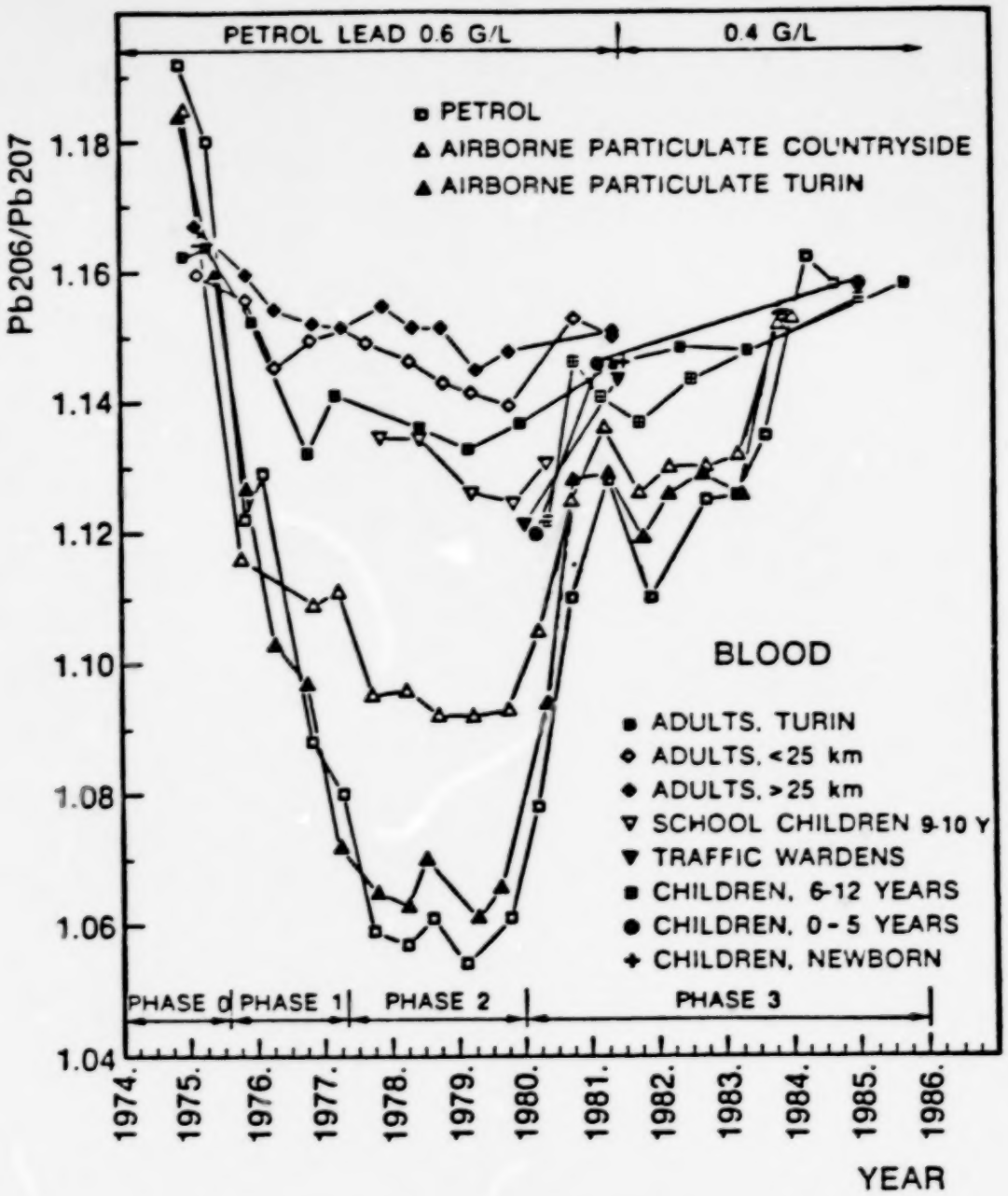


Figure 1. Change in $^{206}Pb/^{207}Pb$ ratios in petrol, airborne particulate, and blood from 1974 to 1985.

The mean difference in the ratio Pb-206/Pb-207 of samples analyzed both in Ispra and in Brussels or in Ispra and in Washington is around 0.001. The behavior of the isotopic ratio in air, on a monthly basis as the average of all the sampling stations both in Turin and in the countryside, shows that the isotopic ratio in the city follows that in petrol more closely than in the countryside.

The isotopic ratio in samples from rural localities during phase 2 of the experiment is significantly different from that in petrol. It should be remembered that as the concentration levels over 24 hours in rural areas (yearly average of 0.28-0.56 $\mu g/m^3$) are much lower than in the city (yearly average value of 2.0 $\mu g/m^3$), sources other than lead from local motor traffic may make a relatively high contribution.

We have evaluated that during phase 2 the airborne lead in Turin contained about 87 percent of Australian lead, i.e. about 1.7 $\mu g/m^3$. During the same phase, in the rural areas, the Australian lead constituted about 59 percent, i.e. about 0.33 $\mu g/m^3$ in the countryside zone within 25 km from Turin and about 0.18 $\mu g/m^3$ in the zone further than 25 km.

It may be interesting to note that the variation of the concentration of lead in airborne particulates has followed closely the variations of lead in petrol which in July 1981 decreased from 0.63 g/l to 0.4 g/l. For petrol the lead concentration ratio for the period 1976-1981 over the period 1982-1984, corresponded to 1.57; for the airborne particulate collected in Turin and countryside in the same periods, the ratio measured was ranging from 1.60 to 1.22.

The difference in lead airborne concentrations between city and countryside is not reflected by the blood lead concentration of males which in the countryside (25-30 $\mu g/dl$) was higher than in Turin (about 22 $\mu g/dl$). This is in contrast to the data from other areas; therefore other factors are presumably acting on the population of the ILE test area. For instance, the lead concentration in tap water in Turin is about 4 $\mu g/l$, while in the country it ranges from 12 to 20 $\mu g/l$. Also, Piedmont is an area of large wine production and consumption. Our lead concentration determinations in 29 Piedmont wines produced from 1970 and 1983 gave an average value of 155 ± 67 $\mu g/l$. As a daily wine consumption of about 0.5-1 liter per day is reasonable for rural drinkers, the importance of wine becomes evident. For similar reasons other dietary differences between city and country may play a role.

As already pointed out, our evaluation is based on the isotopic ratio variation, which should not be affected by the concentration values because during the experiment the lead exposure of the population presumably remained constant. This assumption has been confirmed by the blood lead concentrations of the subjects repetitively sampled from 1975 to 1979, which have shown no significant differences during such a period.

The estimation of the contribution of petrol lead to blood lead was based on measurements either on subjects repetitively sampled from 1975 to 1979 (28 in Turin and 39 in countryside) or on subjects randomly sampled (174 in Turin and 250 in countryside). Consequently, the contribution of petrol lead to blood lead of adults can be estimated around 23 percent, i.e., about 5.00 µg/dl in Turin, and between 8 to 11.9 percent, i.e., from 2.0 to 3.6 µg/dl in countryside (Table 1). These estimations take into consideration both the ingested and the inhaled local petrol lead.

As far as the value of the isotopic ratio of the other external sources of lead in the blood is concerned, values from 1.153 to 1.158 have been evaluated.

The experimental values obtained to date from wines are 1.1642 ± 0.0031 (n=13) during phase 0, 1.1558 ± 0.0041 (n=15) during phase 2 and 1.1608 ± 0.0057 (n=26) during phase 3; for a complete and typical solid diet 1.1458 ± 0.0071 (n=37) during phase 3 (1980); for tomatoes 1.1696 ± 0.0050 (n=2) and coke 1.1573 ± 0.0073 (n=2) both during phase 2; for milk 1.1410 ± 0.0011 (n=4) during phase 2 and 1.1475 ± 0.0037 (n=4) during phase 3.

Introducing Uncertainty: Implications for Approaches and Strategies,
Rolf Hartung

Sizable and largely undefined uncertainties are inherent aspects of risk assessments. The initial uncertainties arise from the design of the experimental protocol. The appropriateness of the animal model, the endpoints to be measured, and the realism of the dosing schedule are almost never assured, and tend to be governed mostly by tradition. The experimental models use either bolus exposures or steady exposures over extended durations. Intermittent or

TABLE 1. FRACTIONAL CONTRIBUTION OF LOCAL PETROL LEAD TO BLOOD LEAD IN PIEDMONT ADULT SUBJECTS
SUMMARY OF RESULTS AND COMPARISON WITH THE STATUS REPORT (SR)[a] FINDINGS

Source of Results	Turin	Countryside < 25 KM	Countryside > 25 KM
Follow-up[b] - Mean X	0.214 (28)	0.109 (28)	0.095 (11)
Follow-up[b] - Median X	0.230 (28)	0.108 (28)	0.080 (11)
Follow-up[c] - Mean X	0.247 (17)	0.119 (15)	0.087 (9)
Follow-up[c] - Median X	0.239 (17)	0.109 (15)	0.080 (9)
Means of Phases 0 and 2 of General Sample	0.237 (124)*	0.119 (107)**	0.089 (62)***
Regression of General Sample - Semestrial Mean	0.221 (174)	0.111 (163)	0.080 (86)
SR Follow-up - Mean X	0.237 (12)	0.125 (19)	0.110 (4)
SR Follow-up - Median X	0.234 (12)	0.118 (19)	0.087 (4)

Figures in parentheses are the number of monitored individuals.

[a]Facchetti, S.; Geiss, F. (1982) Isotopic lead experiment: status report. Luxembourg: Commission of the European Communities; Publication EUR 8352 EN.

[b]All values

[c]Sample size reduced estimate based on individuals sampled in all phases.

*43 subjects in phase 0 and 81 in phase 2

**27 subjects in phase 0 and 80 in phase 2

*** 3 subjects in phase 0 and 59 in phase 2

fluctuating exposures, which are more representative of actual exposures to humans, are almost never considered. The animal models which are used have been selected mostly because of the ease of animal husbandry, or because they represent useful models for specific effects which have initially been found in humans. There are many effects which have been observed in humans for which it has been difficult and sometimes impossible to establish suitable animal models. Conversely, many investigators have expressed reservations concerning the applicability of all effects which have been found in laboratory animals to potential effects in humans. In addition to the controversies surrounding

qualitative differences in responses between species, there are considerable controversies regarding the quantitative differences.

The risk assessment process adds additional uncertainties. The major reasons for this are that risk assessments require extrapolations from the experimental conditions to other species, to other exposure conditions, and to durations of exposure outside of the experimental range.

The extent of the uncertainties cannot be accurately assessed by statistical calculations, because the variabilities found in the conduct of toxicological studies are probably only minor components of all of the sources of uncertainties. Additional uncertainties, which are largely undefined, are introduced during the extrapolation process.

When risk assessments are conducted for protective purposes in order to develop limiting concentrations, then many of the identified uncertainties are used to further reduce the limiting concentrations. This process may involve the use of "uncertainty" factors, "safety" factors, data selection, or the selection of mathematical models which predict higher risks for a specific exposure than other models. In this context it is especially important whether a compound is to be treated as one which elicits toxicological effects which lack a threshold (this is currently reserved for carcinogens), or whether it is considered to elicit toxicological effects which do exhibit thresholds (this is currently reserved for all noncarcinogenic events).

In the case of noncarcinogens, the immense range of potential effects and the difficulty of detecting all conceivable events in animal studies represents a major source of uncertainties. There are many questions concerning the poorly defined extrapolation models for noncarcinogens, which rest largely on safety and uncertainty factors. However, there are no accepted mathematical models for the description of events which are thought to exhibit thresholds.

For carcinogens, the selection of a particular mathematical model for extrapolation is one of the most important sources of different limiting concentrations. It is customary to employ nonthreshold models for the evaluation of carcinogenic effects, even when the experimental evidence tends to support the probable existence of thresholds for a specific compound. Such an approach can be defended when one seeks to establish limiting concentrations to prevent excessive exposures, because of the extensive uncertainties which are inherent in the process. However, predictive models which calculate a most probable risk for an exposure ± the uncertainty are much more difficult to develop, and do not exist at present.

While it is not possible to express the uncertainties in risk assessments in quantitative terms, and while it will not be possible to do this in the foreseeable future, the practice of risk assessment and the public at large would be better served if more efforts were made to state assumptions and uncertainties explicitly.

SESSION II: METHODS FOR MULTIMEDIA ASSESSMENT

In the second workshop session, chaired by Magnus Piscator, the participants focused on tools and methodologies that countries have developed for multimedia risk assessment. Dr. Piscator presented a number of critical design factors that must be considered in developing and interpreting epidemiological studies of pollutants.

Factors of Importance for Planning and Interpretation of Population Surveys, Magnus Piscator

The risk assessment for lead has well illustrated the need for accurate estimates of exposure from different media. In addition to the three major media--air, food, and water--lead can also appear in a variety of other media, e.g., household dust, garden soil, paint, ceramics, drugs, and cosmetics.

However, with the exception of some alkyl lead in ambient air, lead appears in all media as Pb^{+2} and identification of species of lead is generally not needed. However, determination of stable lead isotopes has been shown to be of great value. Determination of total lead in exposure media and in biological media, e.g., blood, gives the necessary information for assessment of exposure. Metabolic models are available for estimates of the fractions of the body burden related to different media.

Other pollutants may cause both pulmonary and systemic effects. Furthermore, they may appear in different species both in exposure media and in the organism, which complicates the multimedia risk assessment.

For example, determination of total arsenic in air, food, and water gives limited information, since arsenic may appear in many species. In air and water, inorganic arsenic in the trivalent or pentavalent state may be dominating, whereas in food from terrestrial sources methylated forms are the major source

and in seafood there are other organic forms (Table 1). There are large differences in toxicity between the species of arsenic, trivalent arsenic being highly toxic and arsenobetaine, a species occurring in seafood, is nontoxic. In addition, certain foodstuffs may contain organic arsenicals used as growth promotors for animals such as chickens. In human beings, arsenic has a complex metabolism. Inorganic arsenic will be methylated and in urine the major part of excreted arsenic will be in this organic form. Arsenobetaine is easily absorbed from the gut, not metabolized and excreted unchanged in urine. Determination of total arsenic in urine may thus give misleading information; determination of species will give more information for assessment of exposure and risk. With regard to retention of arsenic in the lungs and risk for lung cancer, more information is needed on the species of inorganic arsenic in air.

TABLE 1. PREVALENCE OF FORMS OF ARSENIC AND MERCURY IN VARIOUS MEDIA

This table illustrates how substances, in this instance arsenic and mercury, can appear in one form in an environmental medium, but differently in human urine.

	Air	Water	Soil, Plants	Fish	Human Urine
As^{+3}	++	++	+	(+)	+
As^{+5}	++	+	+	(+)	+
Methyl As	(+)	(+)	++	+	++
Arsenobetaine	-	-	-	++	++
Hg^{0}	++	-	-	-	-
Hg^{2+}	(+)	++	+	(+)	++
MeHg	+	-	(+)	++	-

++, +, and (+) indicate relative concentrations in exposure media and urine.

Cadmium is suspected of being a lung carcinogen as well as being recognized as a nephrotoxic agent. Identification of the species that may be carcinogenic is thus important. Recently, it has also been shown that the distribution of

cadmium absorbed from the gut may depend on the proportion of cadmium bound to metallothionein in the diet. Identification of cadmium species in air and in food may thus be of interest for the multimedia risk assessment. However, for determination of cadmium accumulated in the body, determination of total cadmium in organs or urine is sufficient. In population surveys, smoking habits must be taken into account, since smoking may contribute as much to the body burden as dietary intake.

Cadmium and mercury occur in ambient air in relatively low concentrations, which cannot give rise to systemic effects, but the long-term deposition to soil or water can cause increases in basic foodstuffs, which must be taken into account. The formation of methylmercury by microorganisms in water from inorganic mercury which derives from mercury vapor in air is a good example of a multimedia conversion process, which ultimately leads to high concentrations of methylmercury in fish. Population surveys are meaningful only for populations with high consumption of fish or special groups at risk, e.g., pregnant women. Whereas urine is a suitable indicator media for monitoring exposure to arsenic or cadmium, methylmercury must be measured in blood or hair, since it is not excreted in urine. Hair is generally of little use for monitoring uptake of metals, but excellent for estimates of the body burden of methyl mercury.

There are also contaminants which are suspected of causing only pulmonary effects and not systemic effects; nickel and chromium are good examples. Identification of the carcinogenic species in air, i.e., nickel subsulfide and hexavalent chromium, is needed.

Franz Ellermann and Mathias Bock of the Senator for Town Development and Environmental Protection, Berlin, Federal Republic of Germany discussed the Environmental Atlas Berlin and its computer-aided mapping system. A copy of the atlas was on display. The colored maps could not be reproduced in this report; however, two black-and-white samples are included. Information on obtaining a copy of the atlas is available from Franz Ellermann (see List of Participants, Appendix, for address).

Environmental Atlas Berlin, Franz J. Ellermann

History and Presentation of the Problem

The discussion and specification of the purpose and the concept of our joint research and development project were influenced by the recognition of the dimensions of environmental pollution, which citizens--especially those living in densely populated municipal areas--are exposed to, and which politicians have become increasingly aware of. This growing recognition was partly based on increasingly differentiated ways of studying the environment, as for example programs for measures and control implemented by the administration. They were also enforced by the growing interest of scientific research institutions and the universities in this matter. In this context the activities of the Department of Ecology at the Technical University of Berlin deserve special mention.

Another reason for the increasing sensitivity of politicians is probably the increasing interest of the public in environmental protection issues. This is partly due to media coverage and the growing importance of literature on the topic, which have allowed citizens to become better informed. Still more important--especially in big cities--is the direct experience of the daily exploitation of the natural environment, very often leading to its destruction.

The development of new planning bases in the area of urban planning began in the middle 1970's. In 1980/81 the first base-maps were introduced illustrating urban development structures (situational development and analysis) as well as estimates of future requirements, supply analysis, and development trends. Although environmental concerns appeared here for the first time, there was still no sign of a systematic reappraisal which could serve as a basis for new target development and measures programs.

Other factors leading to the development of the Environmental Atlas Berlin were the passing of the Federal Wildlife Protection Law (1976) and the Berlin Wildlife Protection Law (1979). This law demanded the development of a program designed to protect animal and plant life within the whole municipal region of Berlin (suburbs and center). More specifically, the law required an analysis and evaluation of the natural basic condition, the elaboration and physical specification of development objectives for the protection and safety

of nature and environment, as well as the conception of programs and procedural guidelines for the attainment of these objectives. The landscape program, and particularly the special natural resources and environment program, should thus become a base for future municipal area planning and development.

Conception

Because of the above-mentioned problems and tasks, working on the complex of ecological system and environment was not easy at first. There was an abundance of data on the environmental situation stemming from various scientific studies and research programs. However, this was primarily detailed information pertaining mainly to specific problems (such as construction projects) and concerning only small areas or limited time periods. Furthermore, this information had been obtained through a variety of research methods rendering the available results difficult to compare.

Due to the absence of centralized documentation, the availability of data and their usefulness for planning were very limited or depended on personal contracts. Expectations were high for the development of basic guidelines for ecological planning. Specific requirements included the following:

- a very short-term development period (3 years)
- thematically complete starting points
- always covering the whole of the city area
- no additional data gathering
- illustration of all findings in map form
- development and use of methods producing only compatible results
- results should allow differentiations within the city area
- cause-and-effect relations should be made clear
- the environmental atlas should be suitable for updating
- electronic data processing should be used

Since this research and development project was a jointly financed cooperative undertaking with the Federal Department of Environmental Affairs (Umweltbundesamt) it demanded from the very beginning that it have a demonstration character in order to serve as a model to other municipalities. Therefore a division of natural resources into soil, water, air, and climate was made, focusing on the points biotope, land usage, and traffic/noise.

Organization of Work and Realization of the Project

The main objective in this phase of the work was to thoroughly and systematically evaluate the existing data and from these results to design useable guidelines for planning. The following findings should be mentioned: 1) there were far more individual data than had been anticipated; and 2) the condition of this basic material was more chaotic than expected, as most of it had been used for different purposes. This was the case with the data from all fields, including our own.

Cooperation with other fields turned out to be better than anticipated. The amount of work involved was considerably underestimated, as the concept for a number of maps had to be reworked, partly because some subject areas were broadened and partly because we used data from several years in order to identify trends and developments. More than 80 people were employed to work out the maps and to write reports or perform particular jobs, and the coordinators worked a lot of overtime. It took 4 years instead of 3 to complete the project, and 120 illustrations were developed, rather than the 45 anticipated.

Results and Applications

As was already mentioned, we have produced 120 illustrations of Berlin relating either to the different environmental media or to the mode, extent, and distribution of usage. These illustrations have all been completed--the last 10 are presently being printed--and they will be published at the beginning of 1987. We have written accompanying texts to all of these maps, which outline the problem, explain the methods used in the evaluation and processing of data, and comment on the results.

For the design of the land use program, especially in the field of ecological system and environmental protection, the findings in the environmental atlas were summarized on four basic maps: "Soil," "Surface Waters," "Groundwater," and "Air/Climate." In addition to this, the objectives in the preservation of the ecological system were described. Based on the conflicts made clear from these maps, the required measures were then explained and indicated on the corresponding maps.

Two important aspects of this procedure are:

- Such a complete and exhaustive study had never before been undertaken for the city of Berlin.
- Conflicts, causes, and necessary measures were not only verbally described, but were also physically identified and classified.

Perspectives and Future Focus on Tasks

It is indeed remarkable that all obtained results have been published, although they did not always reveal a successful environmental policy. Apart from the final outlines resulting from planning, which by law must include the participation of the public, the ecological guidelines for planning were also published. This elucidated the considerations and the evaluations made during the planning process, making it comprehensible.

Our future work will emphasize a more precise development of measures programs for the preservation of the ecological system. In order to achieve this complex goal, we will start a new research and development project this year in cooperation with the Federal Department of Environmental Affairs. Our objective will be to design and demonstrate a practical "Instrument for Ecological Planning in Berlin," which should take 3 to 4 years to complete. During this period, we will rework and make more precise the initial and provisional measures program, which was designed for the preservation of the ecological system and the improvement of environmental protection. In the reworking of this program, we will stress the need for fast and efficient realization of the required measures.

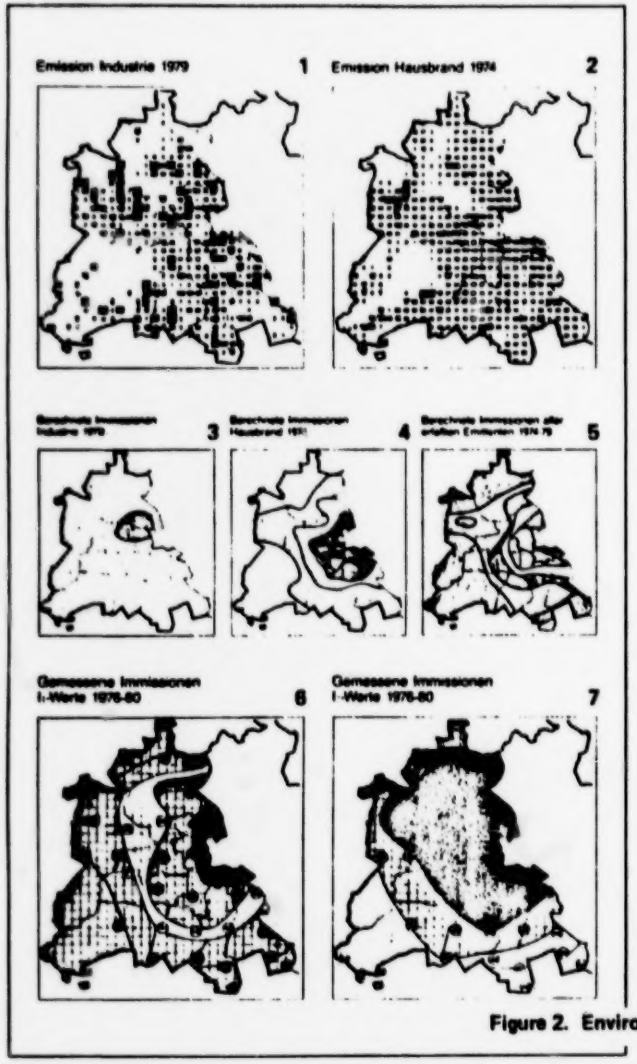
One thing that must be emphasized here is that the passing and implementation by Parliament of our ideas for planning in this or in some similar form does not mean that they will immediately be put into effect. This second step is far more difficult and time consuming than the planning phase itself.

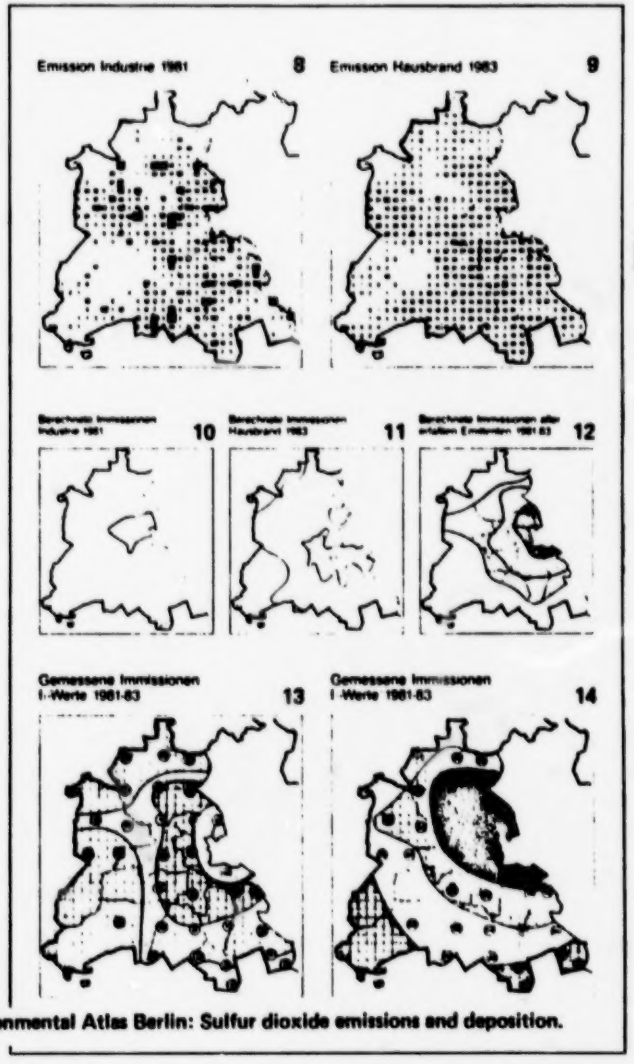
Our work for the Environmental Atlas Berlin and on the designing of a structured land use program has shown us one thing. Because of the information available on environmental matters and ecological requirements, politicians and public authorities are clearly in the position to consider these elements within the framework of their planning and policymaking.

ENVIRONMENTAL ATLAS: BERLIN
GROUND COVER

PERCENT COVERED		
0 TO 15	SPARSE	VEGETATION-COVERED REGION
10 TO 50	HEAVY	DENSELY COVERED WITH VEGETATION AREA OR OPEN DEVELOPABLE LAND
45 TO 75	MEDIUM	VEGETATION RECEDES WITH RESPECT TO BUILDING (DEVELOPMENT)
70 TO 90	STRONG	BUILDING DOMINATED. VEGETATION HERE AND THERE (IN PLACES).
85 TO 100	VERY STRONG	VEGETATION ONLY IN A FEW FRAGMENTS OF LAND.

Figure 1. Environmental Atlas Berlin: Groundcover.





Sulfur Dioxide
Emissions and Deposition

Emissions, tonnes/km²/yr	Yearly means, µg/m³	Deposition values, µg/m³
<2	<8	<40
2-10	8-20	40-80
10-25	20-35	80-120
25-50	35-50	120-160
50-100	50-65	160-200
100-200	65-80	200-240
200-500	80-95	240-280
500-2000	95-110	280-320
2000-5000	110-125	320-360
5000-10,000	125-140	360-400
10,000-15,000	>140	>400

1976-1980

1. Industrial emissions, 1979
2. Housefires emissions, 1974
3. Calculated annual average for industrial sources, 1979
4. Calculated annual average for housefires sources, 1974
5. Calculated annual average (deposition) for all known emitters (industry, housefires (Berlin-East, Berlin-West), remote sources according to OECD study, without industry from Berlin-East), 1974-1979
6. Measured annual averages, means of years 1976-1980
7. Measured deposition values (98% distribution of means), yearly means, 1976-1980

1981-1983

8. Industrial emissions, 1981
9. Housefires emissions, 1983
10. Calculated annual average for industrial sources, 1981
11. Calculated annual average for housefires sources, 1983
12. Calculated annual average (deposition) for all known emitters (industry, housefires (Berlin-East, Berlin-West), remote sources according to OECD study, without industry from Berlin-East), 1981-1983
13. Measured annual averages, means of years 1981-1983
14. Measured deposition values (98% distribution of means), yearly means, 1981-1983

Figure 2. Environmental Atlas Berlin: Sulfur dioxide emissions and deposition.

From Computer-Aided Mapping to an "Ecological Information System," Mathias Bock

The large number of maps to be published in the Environmental Atlas Berlin and the need to update a series of them suggested at the very onset of the project the implementation of automatic mapping techniques. Consequently, computer-aided mapping, which seemed an economical and effective method for producing printer's copies, was started in November 1984 with aid from the Umweltbundesamt (Federal Department of Environmental Affairs) and the Siemens Company.

A workstation connected to a Siemens Host-Computer supplied by the Department of Environmental Affairs and equipped with Graphic-Tablett, hardcopy unit and Calcomp-drumplotter formed the hardware of the graphic software package SICAD, which is composed of programs for interactive designing of maps and graphic interpretation of data (Figure 1).

In order to obtain results at the earliest stages of the project, only simple maps and schemata were at first produced. Then, using an enlarged overview map of the city area with a scale of 1: 50.000, the city and district limits were digitized as well as all rivers and lakes, railways, and the main motor vehicle traffic arteries. The resulting structures and areas could then be supplemented with data, concerning, for example, the condition of shorelines or the burden of motor vehicle traffic on the environment.

The next step was the attempt to interpret graphically the numerous available data, concerning matters such as the condition of lakes and rivers and air pollution. To obtain this graphic interpretation, schemata supplemented with coded areas were produced, making it possible to draw up a large number of individual maps founded on the numerical data supplied by various data files (Figure 2).

In order to apply this simple and convenient method to the detailed illustration of the municipal area, the digital base map was elaborated in such a way that each homogenous section of the city would have its own code. This was started in March 1986.

For the demarcation of these sections, statistical area units, the actual land use and the structures of undeveloped areas resulted in close to 25,000 separate sections, approximately 120,000 borderlines, and almost 200,000 points of reference. All information concerning the municipality and relevant to the

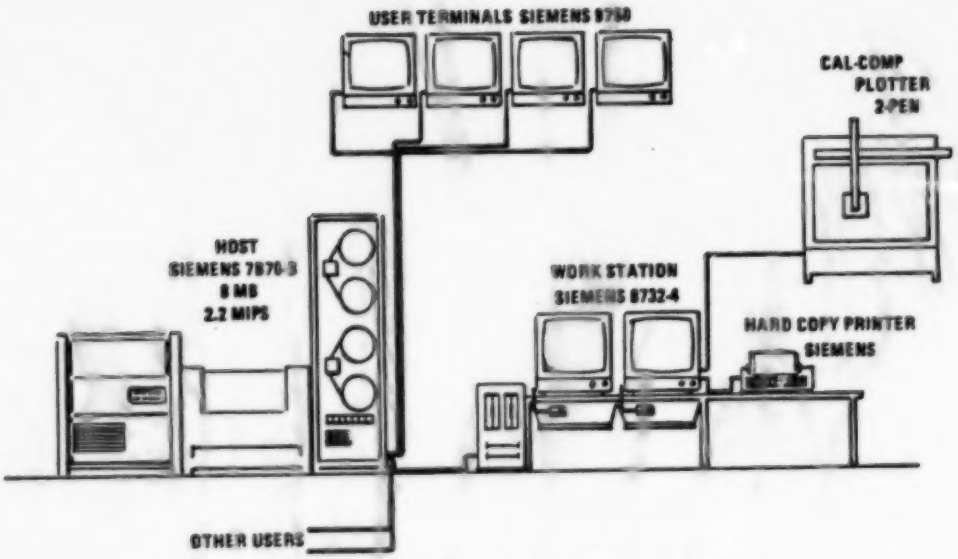


Figure 1. Siemens graphic workstation.

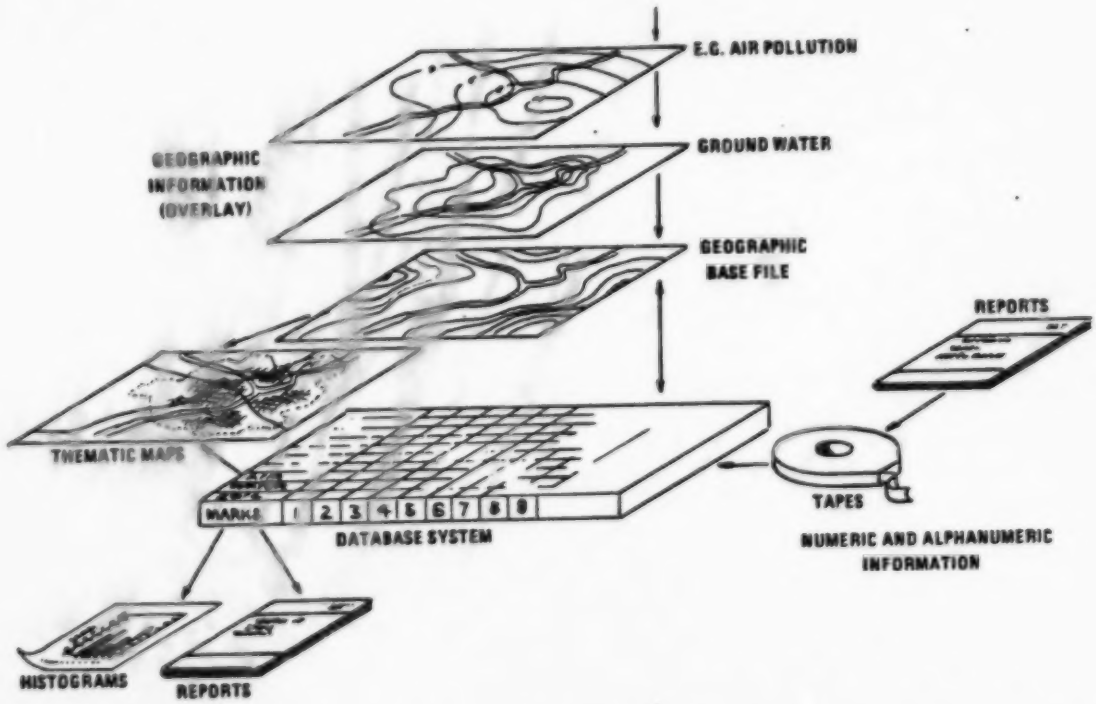


Figure 2. Schematic showing flow of information input to database system to produce histograms and reports.

environment shall then progressively be assigned to a section, borderline, or reference point and be stored in a data bank system.

The processing and evaluation of this data will allow the labeling of burdening as well as sensitive areas. Overlapping these will help identify areas of conflict. The required conceptual content for this will be available by the end of November. Scenarios and trend-analyses can then be used to pose "if-then" questions essential to the decision-making process as well as to test specific alternative measures.

Our ultimate aim is to further develop this user-software in a way that will allow every user, in accordance with the concept of an ecological information system, to make comprehensive analyses of environmental conditions without special computer training, and to be able to represent the results of their analyses graphically.

The experience resulting from our work has shown that only in wide-ranging and comprehensive projects requiring all of the system's functions and capabilities is the graphic data processing method worth using. To use it exclusively for making printer's copies has proven too expensive in comparison with manual techniques.

Furthermore, we consider it no longer possible to deal with the ever-increasing problems of environmental management without the assistance of modern graphic systems with their wide-ranging capabilities. Conventional procedures are no longer suitable in meeting the growing demands of this complex field.

The next presentation, by Margrit von Braun of TerraGraphics, Inc., and the University of Idaho, featured a demonstration of the Professional Map Analysis Package (pMAP©), a Geographic Information System (GIS). The pMAP© demonstration illustrated how GIS technology was used to determine hazard zones and develop procedures for cleanup of lead contamination near a smelter.

GIS: A Multimedia Tool for Environmental Analysis, Margrit von Braun

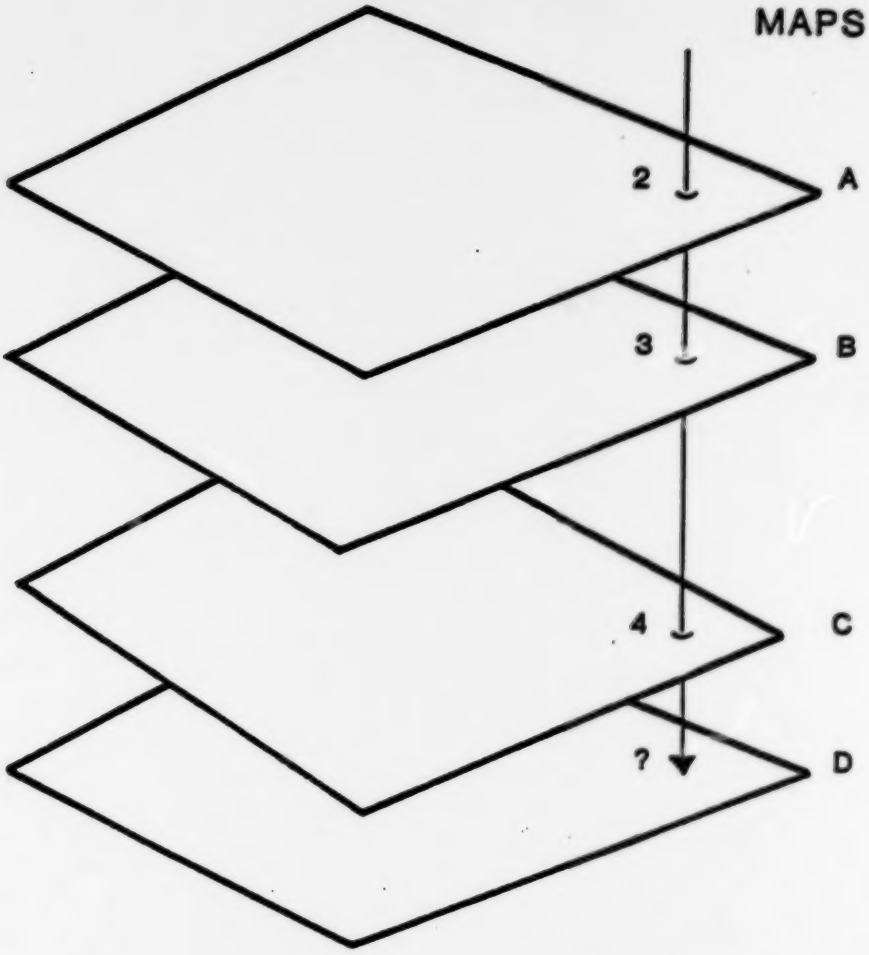
Assessing the impact of environmental pollution in several media requires the collection, analysis, and management of large amounts of data. These data often represent spatial information planes such as the geographic distribution of a pollutant, housing patterns within a specific study area, and the topographic profile of a site. The integrated, simultaneous analysis of these data planes offers an immense multidisciplinary challenge in many environmental cleanup strategies. Additionally, pollution problems are often subject to intense community, political, and economic concerns.

The emergence of Geographic Information Systems (GIS) promises to enhance the data management and decision-making processes currently used in assessing environmental problems. GIS are computer based systems that encode, store, retrieve, manipulate, and display data stored as "computer maps." These spatial data typically originate from a variety of sources and formats. Cartographic modeling capabilities of GIS allow concurrent analysis of the data planes or maps.

The Professional Map Analysis Package ("pMAP"©) was used in the workshop demonstration. This grid-based geographic information system includes analytic capabilities organized as a set of mathematical operations, which, like traditional algebra, may be combined to perform a variety of map analyses. This "map algebra," demonstrated in Figures 1 and 2, forms a structure for data base management, spatial statistics, and cartographic modeling.

GIS technology was applied to a soils contamination problem at a secondary lead smelter in an academic demonstration of GIS capabilities. The RSR facility in West Dallas, Texas operated battery recovery operations from the World War II era until 1984. Excessive emissions from the plant resulted in gross contamination of adjacent residential soils. In 1982, studies of childhood blood lead absorption indicated that 14 percent of preschool children 1/2 mile from the smelter had blood lead levels in excess of 25 µg/dl. Subsequent court actions required removal and replacement of contaminated soils in residential areas.

A GIS data base was created with maps representing soil lead concentrations, land use, housing densities, and streets in the vicinity of the RSR smelter, as shown in Figure 3. Spatial estimation techniques, demonstrated three-dimensionally in Figure 4, were used to determine hazard zones based on



SAMPLE MAP COMBINATIONS:

ADD A TO B TO C FOR D- - - - - - - - - - (D = 9)
AVERAGE A AND B AND C FOR D- - - - - - (D = 3)
MAXIMIZE B AND C FOR D- - - - - - - - - - (D = 4)

Figure 1. Maps combined point-by-point using traditional algebraic techniques.

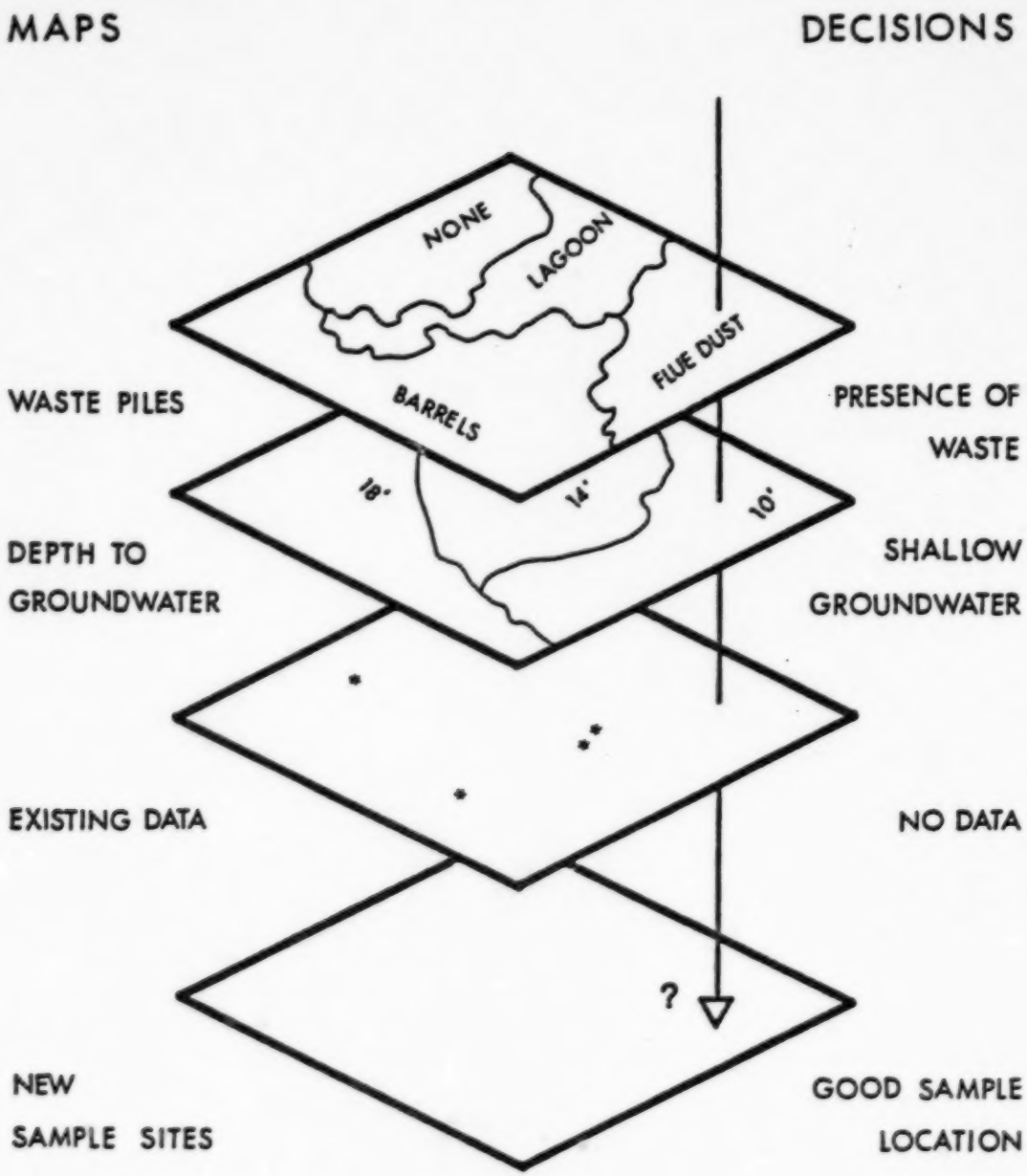


Figure 2. Neighborhood features of maps combined using Boolean Algebra approach.

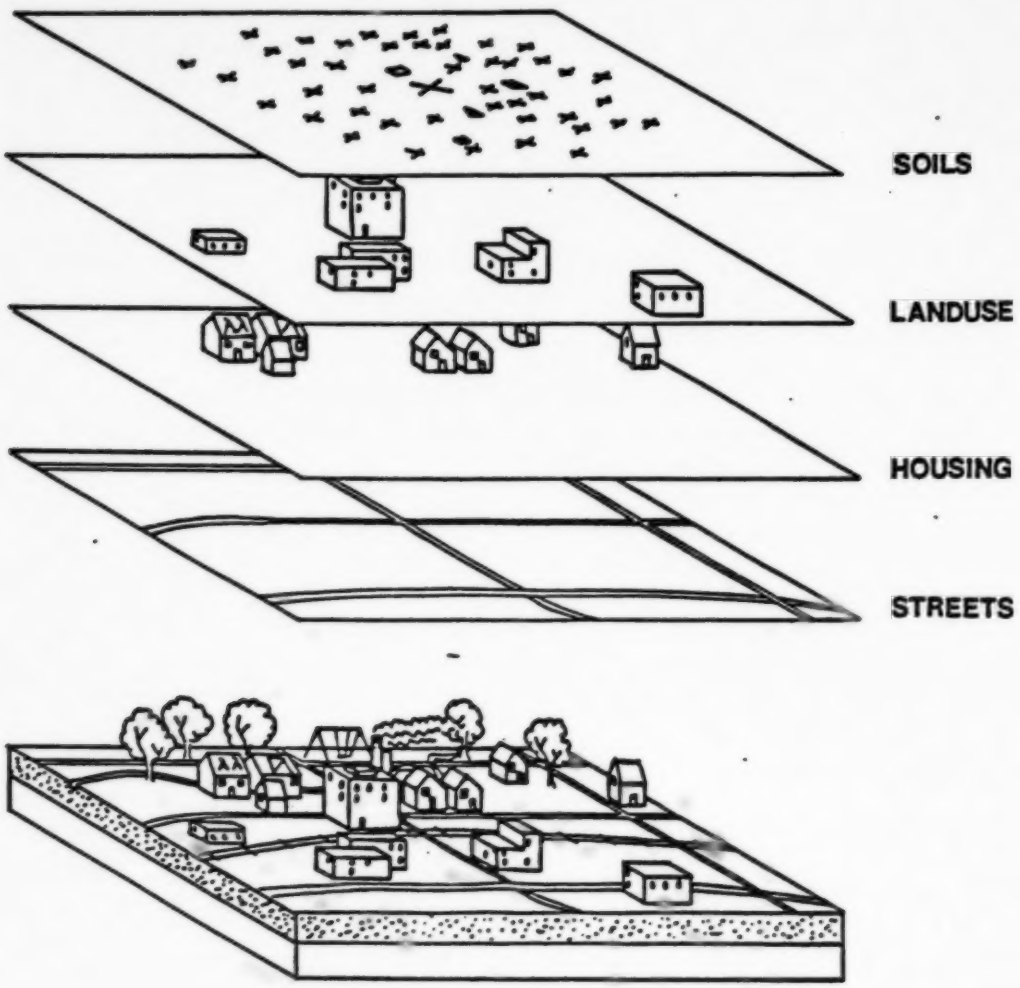
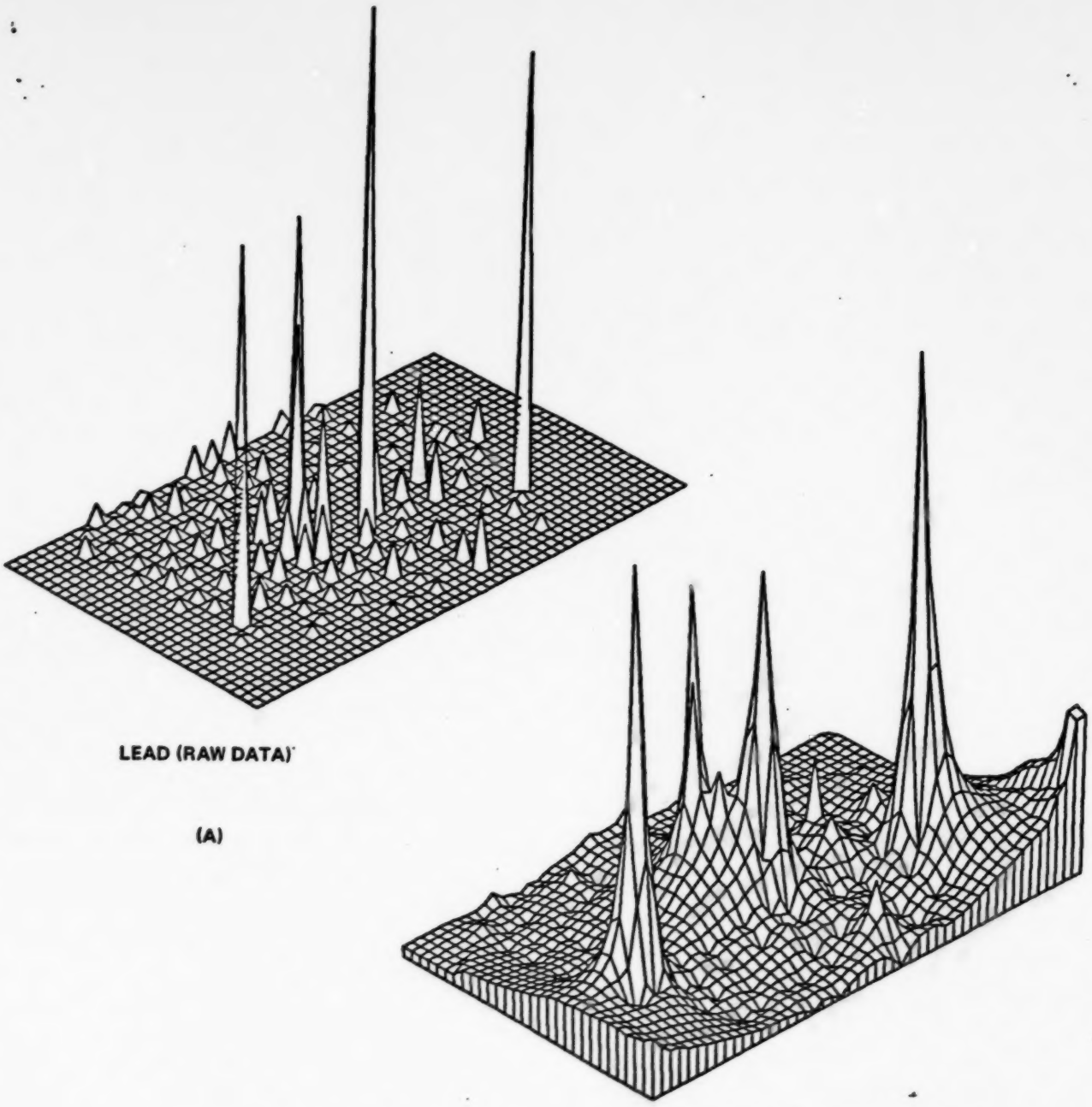


Figure 3. Four base maps comprising GIS database for smelter site.



LEAD (RAW DATA)

(A)

LEAD, SURFACE–INVERSE DISTANCE SQUARED (IDS) INTERPOLATION

(B)

Figure 4. Spatial estimation techniques are used to convert sampled lead concentrations (A) to area-wide estimations (B).

soil lead levels. The resulting "hazard zone" map was overlaid with population and housing maps using GIS techniques to generate cross-tabulations such as numbers of persons and dwellings and types of dwellings within each hazard zone. These results allow optimization of cleanup scenarios in terms of benefits to specific populations and housing groups.

GIS reclassification procedures were then used to develop cost estimates for the scenarios. Assumptions were made regarding disposal requirements for excavated soils based on projected concentrations, costs of excavation and removal based on dwelling type, costs of health and safety precautions based on concentration and population proximity, and costs for street berm and housing cleanup. Figure 5 and Table 1 represent a "map flow chart" of these analyses. As a final exercise, the movement of cleanup crews was modeled utilizing transportation analysis techniques available in the GIS.

The flexibility and analytic capabilities of GIS offer great potential in the analysis of environmental contaminants. The interdisciplinary problems encountered at many waste sites require integration and concurrent analysis of results from different media and different disciplines. Use of a common GIS format for all data planes relevant to a site analysis enables efficient, simultaneous evaluation. Future GIS applications promise to enhance traditional management and decision-making processes in waste site analyses.

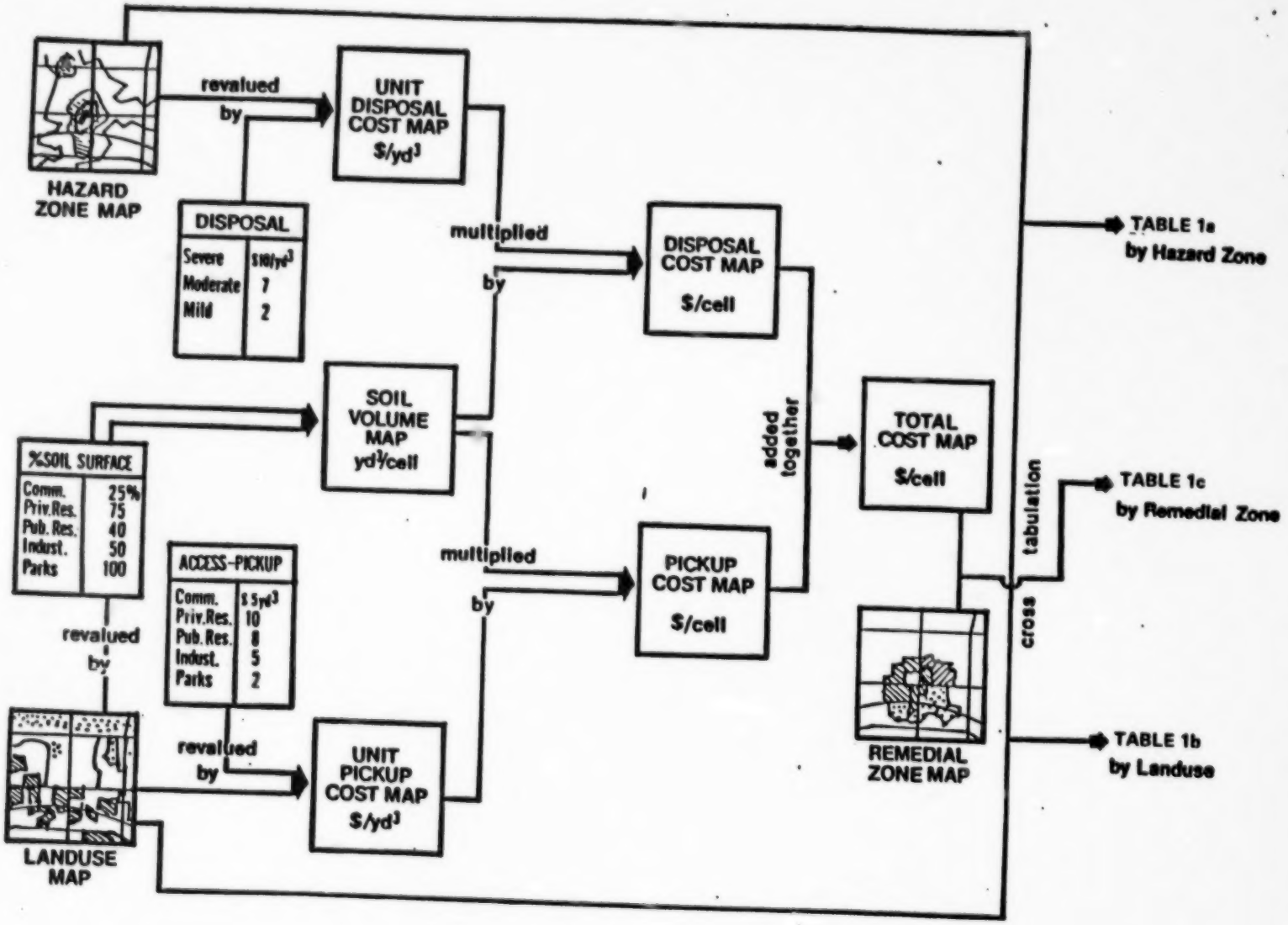


Figure 5. Map analyses used to estimate costs of various cleanup scenarios detailed in Table 1a-c.

TABLE 1. TYPICAL REMEDIAL SCENARIO COST CROSS-TABULATIONS

1a - Soil Remedial Cost by Hazard Zone

Hazard Zone	Area (Ac)	Pickup ($K)	Disposal ($K)	Totals ($K)
Severe	168	440	593	1023
Moderate	202	484	543	1027
Mild	566	1198	367	1565
	936	2122	1503	3625

1b - Soil Remedial Costs by Hazard Zone and Landuse Class

	Soils Cost ($K)			
Hazard Zone	Residential	Parks Undeveloped	Commercial/ Industrial	Totals
Severe	699	40	294	1033
Moderate	712	241	74	1027
Mild	1129	239	197	1565
	2540	520	565	3625

1c - Soil Remedial Costs by Remedial Zone

Remedial Zone	Soils/Cost ($K)
A - Private	333
A - Public	399
B - Private	820
B - Public	988
B - Park/Undeveloped	520
C - Commercial/Industrial	565
	3625

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The mission and functions of the National Enforcement Investigations Center (NEIC) in U.S. EPA, Region VIII were discussed by James L. Hatheway, with special emphasis on the area of multimedia compliance audit. Participants also inspected NEIC's mobile lidar facility and mobile laboratory, which were brought to the workshop site for a demonstration of equipment and techniques.

National Enforcement Investigations Center, James L. Hatheway

The National Enforcement Investigations Center was established in 1970 as an enforcement arm of the U.S. EPA. Inspectors conduct multimedia compliance audits of facilities that discharge, emit, handle, or dispose of pollutants controlled by Federal, State, or local environmental laws and regulations. These include the following major Federal acts: The Clean Air Act (CAA), the Clean Water Act (CWA), the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA/ Superfund), the Toxic Substances Control Act (TSCA), the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), and the Safe Drinking Water Act (SDWA).

Waste sources must comply with national standards for controlling the handling, emission, discharge, and disposal of harmful substances, whether the programs are implemented directly by the EPA or delegated to the States. In most cases, the national standards are applied to sources through permit programs which control the release of pollutants into the environment. The EPA establishes the Federal standards and requirements and approves State programs for permit issuance.

The States can set stricter standards than those required by Federal law. Some of the larger programs which have been delegated by the EPA to qualifying States are the National Emissions Standards for Hazardous Air Pollutants (NESHAP), and the Prevention of Significant Deterioration (PSD) permits under the CAA, the Water Quality Standards and the National Pollution Discharge Elimination System (NPDES) programs under the CWA, the Hazardous Waste Program under RCRA, and the Drinking Water and Underground Injection Control (UCI) programs under the SDWA. Conversely, TSCA is administered entirely by the Federal Government.

The NEIC investigative methods integrate enforcement programs in air, water, solid waste, and toxic substances. The purposes of a multimedia

compliance audit are to review a facility's pollution control practices, inspect waste handling equipment, evaluate waste handling procedures, and determine the status of compliance with applicable laws and regulations. Emphasis is given to identifying violations of regulations, permits, approvals, consent decrees, etc. and the underlying causes of the violations. Given the number of environmental laws and regulations which may apply to the facility, an indepth review cannot always be made. However, the inspectors are to conduct as thorough a review as possible so that violations and problems that have an existing or potential effect on the environment are identified.

Pollution sources vary in complexity depending on facility size, process operations, and the number of pollution programs involved (e.g., air, water, solid waste, toxic substances). Therefore, the time and personnel resources required vary accordingly. For example, a large industrial facility with multiple process operations may require consideration under several of the environmental laws listed above. A multimedia compliance audit of this magnitude requires an audit team with sufficient combined experience to effectively audit the pollution potential of the facility.

The specific objectives of multimedia audits are to:

- Document facility compliance with environmental laws, regulations, permits, consent decrees, and approvals.
- Determine ability of a facility to maintain "continuous compliance" across all environmental areas.
- Identify need for remedial and/or reinforcement action to correct the causes of violations.

Heinz Davidsohn of the Environmental Authority of the State of Hamburg made a presentation on a comprehensive ecological assessment of the coastal area in the region where the Elbe River enters the North Sea. This assessment was conducted to provide multimedia information for land use planners, administrators, and decision-makers regarding protection of the environment and public health.

Ecological Assessment of the Lower Elbe Region, Heinz Davidsohn

The project presented to CCMS was directed by the Department for Supra-regional Affairs in the Environmental Authority of Hamburg. Mr. H. Davidson is head of the department. The feature of its work is to advise the board's policy in relations to other states and to the federal government, i.e., to prepare decisions and activities for the conferences of the ministers for the protection of the environment and in the "Bundesrat," the second chamber of the German parliament.

The study, "Ecological Assessment of the Lower Elbe Region," covers a part of the coastal area of the Federal Republic of Germany, a strip of land along the estuary of the Elbe from the border of the German Democratic Republic to the North Sea. Parts of the territories of the states of Schleswig-Holstein and Lower Saxony and the state of Hamburg are included. The total area amounts to 4,400 square kilometers inhabited by 2-3 million people. The region is a focal point of economic activities as well as of extreme importance as a natural biosphere.

During the last two decades, large industries and power plants settled along the Elbe, motorways were laid, dredging of waterways was enhanced, and wide wetlands were separated from the influence of tide by dikes. Though the process is slowing down, some projects will still be realized in the future. The protection of resources like fertile farmland and groundwater, landscape, and nature had no priority.

Growing consciousness of ecological problems forced politicians and authorities to respect these questions in planning land uses. A consulting company, Dornier-System Ltd., was hired and assisted by the states of Bremen, Hamburg, Lower Saxony, and Schleswig-Holstein, under the sponsorship of the Federal Environmental Agency. Their objectives were:

- To elaborate information about and to assess the state of the environment,
- To describe the conflicts between impacts and ecologically sensitive areas, and
- To comment on the existing plan for land use, to point out restrictions against certain projects, and to propose measures to improve the situation.

The experts finished their work in January 1986. The environmental boards of the three states collected their data relevant to ecology, and sent them to the consultant. There they formed a homogeneous picture, derived the information, represented the results as maps, and commented on them. The state of the environment is described in terms of:

- land uses
- air pollution
- noise impacts
- discharges and quality of surface water
- potential of and hazards to groundwater
- value of soil for agriculture and risks of contamination
- value of landscape for human recreation and impacts
- value of landscape for the conservation of nature and impacts
- summarized restrictions against non-natural land uses.

From these results comments and recommendations have been derived, according to the projects described in existing land use plans. The areas included are:

- the spatial development as a whole
- new residential areas
- new industrial areas
- new traffic routes
- new power plants
- recreation reserves
- dredging and disposal of dredge
- groundwater reserves
- nature reserves
- political decisions
- improvement of planning methods.

The study helps determine which impact is the most severe and what measures have to be taken primarily to adapt the development to the natural potential. Air pollution turns out to be a major stress for the inhabitants of Hamburg, where it is mainly due to emissions from automobiles. Pollutants from high sources are raising the contamination level only slightly above the

background. Compared to air pollution, the natural biosphere is more affected by dissection and too close neighborhood of non-natural land uses. Considering all possible impacts, the planned expansion of industrial areas and roads is highly restricted.

In the states of the Federal Republic, central planning boards are guiding the spatial development. Within that frame, counties and municipalities work out the details. One basic principle demands that economical, social, and ecological interests have to be balanced. However, conflicts between those interests became obvious, and deficits of the traditional way of planning were disclosed in the course of enhanced industrialization. The deficits were:

- The sometimes excessive demands of the single states were not harmonized and reduced by agreeable compromises. The differentiated spatial regulation concept (1979) ordered by the Ministers President of the four states could not fulfill this task.
- Locations for industry, harbors, and power plants were offered in large excess. These sites are far from being filled up today. The companies that settled there took advantage of the competition of states. Planning suffers from the surprising fact that the boards do not keep current inventories of land uses.
- The public could not participate sufficiently. Some projects were fought fiercely.
- The weights of ecological demands were often singled out, and thus each on its own could not compete with economic advantages.

The Ministers for the protection of the environment of the four coastal states recognized at their last session on September 15 that the study is the first attempt for a coherent and comprehensive environmental impact assessment of the entity of developments of the lower Elbe region. They proposed to their Ministers President to revise the differentiated spatial regulation concept, provided that other relevant data, especially economic data, would be actualized.

Though the ecological assessment reduces the deficits mentioned above, planning boards resist implementing it into the process. Environmental impact statements are not required yet by German law. Presently it depends on political will to introduce cross-media environmental planning. The political

situation, especially in Hamburg, is favorable for such a change in the planning process.

The next presentation, by Paolo Ciccioli of the Istituto sull' Inquinamento Atmosferico in Rome, focused on evaluation of the health hazard potential of diesel exhaust through the use of screening tests of biological activity to guide analysis, especially chemical characterization.

Diesel Exhaust Emissions: An Air Pollution Problem Requiring a Multimedia Approach for Risk Assessment, Paolo Ciccioli

In the last few years, vehicular emission has become one of the major sources of air pollution in Italy. According to recent estimates (1), it accounts for 65 percent of nitrogen oxides, 55 percent of particulate matter, 90 percent of CO and 90 percent of volatile organic components (VOC) emitted into the environment by all industrial processes and domestic heating. Such a relevant impact is strictly related to the different policy adopted, in our country, for stationary and mobile sources. The increased adoption of natural gas for domestic heating, the limited consumption of coal (10 percent) and the widespread use of oil (84 percent) for energy production coupled with several efforts made by our government and the population to save energy (domestic heating has been limited, by law, to 8 hours a day and to 6 months a year), has allowed maintaining emission from stationary sources at the same levels reached in 1974. By contrast, the number of cars sold each year has increased constantly during the same period of time. In 1986 about 22 million cars were circulating in our country, not taking into account the additional input of 2 to 3 million vehicles arising from foreign visitors in Italy for tourism, study and work. The relevance of mobile sources emission can be better understood by comparing the situation developed in Italy with that observed in USA. Although the number of cars per each inhabitant living in Italy is still lower than that reached in USA, the average density of vehicles, measured per each square km or

km or existing roads by assuming an homogeneous distribution of emission sources, is already three to four times higher than that measured in USA. If we use instead, the emission inventories for particulate matter, nitrogen oxides, CO and VOC to estimate the emission strength intensities for mobile sources, we can see that the values obtained depend upon the type of pollutant considered and, in any case, their ratio is not the same as that expected on the basis of cars density. While the emission densities (measured in metric tons per square km per year) estimated for black particles and nitrogen oxides emitted by mobile sources are, respectively, 7 and 4 times higher than those measured in USA, values for CO and VOC are only twice as large as those calculated for the USA. Since the emission inventories have been made by using fuel consumption and the same emission factors (EPA source), the large difference between particles and gases can be explained only by assuming that the relative contribution of various mobile sources is different in the two countries. In particular, the different inputs arising from diesel- and gasoline-fueled vehicles can explain the trends of pollutants followed in these two countries. If we look at the data shown in Table 1 we can see that a substantial increase in diesel-powered vehicles should give rise to a dramatic uptake of particles and, to a lesser extent, of nitrogen oxides whereas equal or even lower amounts of CO and VOC should be observed in air. The explanation that differences in emission densities between USA and Italy depend upon the percentage of diesel-powered vehicles, is strongly supported by the data shown in Figure 1, where the trends of diesel vehicle sold in Italy, Europe, and USA in the last ten years are reported. From these figures, it is possible to estimate that the average density of diesel vehicles in Italy, measured by assuming an homogeneous distribution over the whole territory, is 30 times as high as that observed in USA. If we take into account the additional contribution arising from agricultural and military vehicles, power generation systems for field use and ships, we can estimate that average people living in large cities can be exposed to about 30 to 50 $\mu g/m^3$ of diesel soot. These values are 1 to 2 orders of magnitude higher than those experienced now in many American cities. It might be argued, at this point, that total mass of black particles can be taken only as a very rough indicator of the potential hazard to human health because of the wide difference in the size of particles emitted by combustion sources and the content and nature of organic material absorbed on soot. While it is well known that diesel particles are rather small in diameter (0.15 μm) and,

TABLE 1. TYPICAL VEHICLE EMISSION (g/km)

Vehicle Type	Particles	Nitrogen Oxides	CO	Hydrocarbons
Light-duty Diesel	0.1-0.4	0.5-2	0.5-3	0.05-0.8
Light-duty Gasoline	0.001-0.004	0.2-1	1-3	0.08-0.5
Heavy-duty Diesel	0.5-4	3-20	5-50	0.9-0.6
Heavy-duty Gasoline	0.004-0.2	1-11	10-200	0.9-0.6

Data taken from Ref 2.

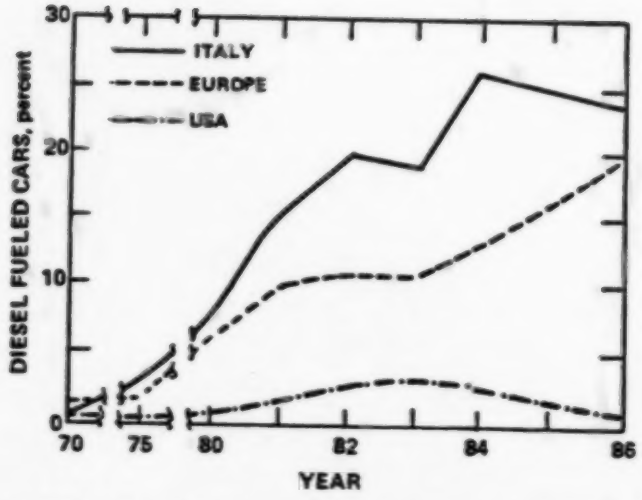

Figure 1. Percent of light-duty Diesel cars sold in Italy, Europe, and USA in the last 10 years.

therefore, they can easily reach the tracheobronchial and pulmonary region, more detailed information on their potentially hazardous properties can be gained by submitting the extracted material to short-term biological assays capable to show whether and to what extent mutagens and carcinogens are present in the emission source. Table 2 reports a comparison between the mutagenic properties of diesel exhaust emission and other mobile and stationary sources. The results were obtained by using the Ames test without activation and are expressed as the number of revertants per each kg of fuel consumed. By looking at this table we can conclude that in the Italian situation, where oil combustion is by far the major source for power generation and natural gas is increasingly used for domestic heating, diesel exhaust emission might represent a rather important source of outdoor risk for the population living in densely populated areas as emission occurs very close to where the people live or work.

TABLE 2. COMPARISON OF EMISSIONS FROM ENERGY PRODUCTION AND EXHAUST FROM VEHICLES

Combustion Sources	Revertants/kg/fuel Consumed
Coal, 5 MW	1,400,000
Coal, 395 MW	2,000
Coal, 350 MW	2,000
Oil, 37 MW	15,000
Oil, 680 MW	700
Wood chips, 30 MW	15,000
Wood chips, residential burners	330,000-2,200,000
Diesel Engine	2,000,000
Gasoline Engine	200,000

Data from Ref. 4.

Based on the above considerations, several efforts have been recently devoted to the speciation and quantitation of organic components present in diesel exhaust and environmental samples with the aim of identifying those constituents that may account for the biological properties of this type of mobile source. Our approach has been that of exploiting a combination of low

and high resolution chromatographic techniques to achieve this goal. After extraction of particles, the solution is fractionated on a semi-preparative alumina column in order to separate direct mutagens and carcinogens from the rest of the sample (see Figure 2a). The moderately-polar fraction, eluted by acetonitrile, is further separated on a HPLC silica column, working in gradient elution, in order to collect subfractions containing components having different molecular size and biological activity (see Figure 2b). Positive identification combined with specific detection (electron capture, alkali flame and mass spectrometry). A list of components identified in the moderately-polar fraction extracted from a diesel exhaust emission, a sample collected from the stack of an industry manufacturing carbon electrodes and urban particulate matter are reported in Table 3. Among these components, nitrated-polyaromatic hydrocarbons (nitro-PAH) in general and particularly 1-nitropyrene, are the most abundant and powerful direct mutagens and human carcinogens present in diesel exhaust samples. Although nitro-PAH can be also found in some industrial sources, they serve well as indicators of vehicular emission in urban areas

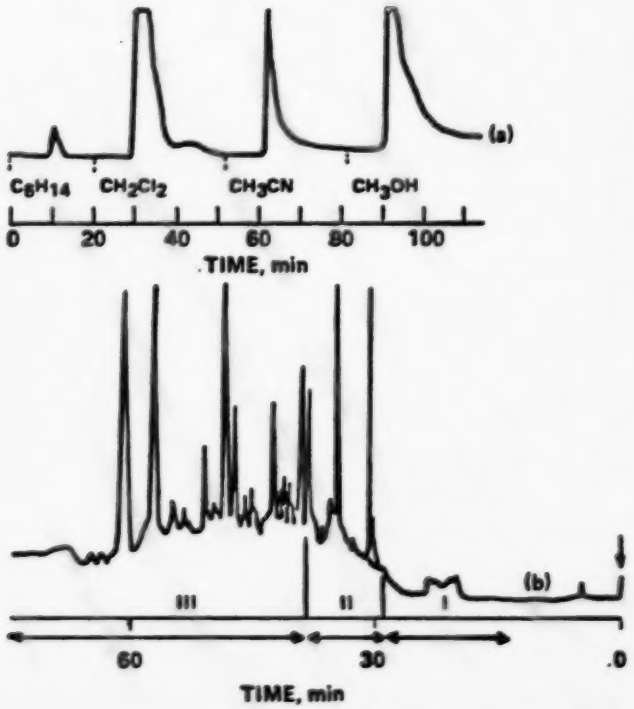

Figure 2. (a), Low resolution chromatographic separation of the organic fraction extracted from a Diesel exhaust sample.
(b), High resolution liquid chromatographic separation of moderately-polar fraction (CH_3CN eluate) collected during the semipreparative separation shown in the previous figure. Numbers in romanic are used to identify the subfractions collected for the identification by CG/MS.

TABLE 3. MODERATELY POLAR PAH IDENTIFIED IN THE HPLC SUBFRACTIONS OF A DIESEL EXHAUST, AN INDUSTRIAL EMISSION, AND URBAN PARTICULATE MATTER

N	Compound[a]	M.W.[b]	S.B.[c]	Concentration, µg/g dust		
				D.P.[d]	I.E.[e]	U.P.M.[f]
1	Benzothiazole	135	III	-	+	-
2	9H-Carbazole	167	I	-	+	-
3	Benzoquinoline	179	I	-	+	-
4	9H-Fluoren-9-one	180	III	+	+	-
5	Methylcarbazoles	181	I	-	+	-
6	Benzophenone	182	III	-	+	-
7	9(10H)-Anthracenone and phenanthren/anthracen-x-ones	194	III	+	+	-
8	Dimethyl or ethylcarbazoles	195	I	-	+	-
9	9H-xanthen-9-one	196	III	-	+	-
10	Azafluoranthenes/pyrenes	203	III	-	+	-
11	4H-Cyclopenla[d,e,f] phenanthren-4-one	204	III	+	+	-
12	9,10-Anthracenedione	208	III	+	+	+
13	Methylethylcarbazole	209	I	-	+	-
14	Oxo-X,Y-dihydrodibenzoxepin	210	III	-	+	-
15	2-Nitrofluorene	211	II	<0.1	<0.1	-
16	Benzocarbazoles	217	II	-	+	-
17	Coumarin (from PAH with M.W. 202)	220	III	-	+	-
18	Methylanthracene/phenanthrene-X,Y-dione	222	III	+	+	+
19	9-Nitroanthracene	223	II	<0.1	0.1	-
20	X-Nitroanthracenes/phenanthrenes	223	II	<0.1	1.5	-
21	Cyanopyrenes/fluoranthenes	227	III	-	+	-
22	11H-Benzo[x]fluoren-11-one or XH-benzo[d,e]anthracen-X-one	230	III	+	+	+
23	X,Y-Diphenylpyridine	231	II	-	+	-
24	Benzothienoquinoline	235	III	-	+	-
25	Methyl derivatives of compound n:22	244	III	+	+	+
26	X-Hydroxybenzanthacenone	246	III	-	+	-
27	7-Nitrofluoranthene[g]	247	II	-	3.0	-
28	1-Nitropyrene	247	II	8.0	1.0	0.7
29	6H-Benz[c,d]pyren-6-one	254	III	+	+	+
30	Benzanthracene/phenanthrene-X,Y-diones	258	III	+	+	-
31	Methylnitrofluoranthenes/pyrenes	261	II	0.3	<0.1	<0.1
32	Dibenzocarbazole	267	III	-	+	-
33	12,14-Furanoanthracene-12,14-dione	276	III	-	+	-
34	XH-indeno[X,Z-x]phenanthren/anthracen-X-one or XH-dibenzo[x,y]fluoren-X-one or XH-dibenzo[x,y,z]phenanthren/anthracen-X-one	280	III	+	+	-

[a]Capital X and Y are used to indicate isomeric components in which the position of the group cannot be identified by MS. Lower case x and y are used when it is not possible to identify the relative position of the benzene rings.

[b]M.W. = molecular weight.

[c]S.B. = subfraction.

[d]D.P. = diesel exhaust.

[e]I.E. = industrial emission.

[f]U.P.M. = urban particulate matter.

[g]This compound was later identified as 2-nitrofluoranthene isomer.

Source: (Ref. 5)

where stationary sources other than domestic heating are unlikely to be present. The usefulness of nitro-PAH for evaluating the risk associated to diesel emission can be better seen from the results shown in Figure 3 where Ames assay liquid chromatograms (6), obtained during the analysis of particulate matter emitted by a light-duty diesel-powered car, is reported. From these profiles we can see that 1-nitropyrene gives always the highest response and accounts, by itself, for a large fraction of the whole mutagenic properties of the extract. The fact that it has been possible to obtain similar profiles from air samples collected in the Allegheny Tunnel (USA), where fairly high concentrations of diesel vehicles were observed, indicates that 1-nitropyrene can be used as a possible indicator of diesel exhaust emission in environmental samples. In many instances, however, the sensitivity of Ames assay chromatography is not sufficient to detect nitro-PAH in environmental samples and better resolution and sensitivity can be gained by combining chromatographic techniques with mass spectrometry working in selected ion monitoring. A comparison of GC-MS profiles obtained during the analysis of nitro-pyrene/fluoranthene particulate matter sampled in downtown Rome are shown in Figure 4. From these results it is possible to see that this method allows a fairly good quantitation of 1-nitropyrene in very diluted samples even in the presence of other isomeric species that can be formed in air because of photochemical smog reactions.

In order to evaluate the contribution of diesel soot to the total amount of particulate matter present in air, it is important to know what is the average content of 1-nitropyrene in diesel emission. Since this value changes drastically with the type and size of engine and the way the car is run, laboratory experiments, simulating different working conditions, were carried out in our Institute on a light-duty diesel-powered car. By combining our results with those obtained in the literature, an average content of 2-3 μg of 1-nitropyrene per gram of dust were estimated to be present in particles emitted in urban areas where rather low traffic speed is observed. Aerometric determinations carried out on samples collected in Rome, at the fifth floor of a building located within the historical center, have shown that about 10 to 15 percent of total suspended particulate matter originated from diesel emission. By considering that about 70 percent of this value is represented by carbonaceous particles (60 to 70 $\mu g/m^3$), we arrive at an average concentration of 18 to 30 $\mu g/m^3$ of diesel particles in air. It can be estimated that during winter, when higher traffic densities are reached, values ranging between 40 to 60 $\mu g/m^3$ can be experienced by the population. Although it has been estimated that

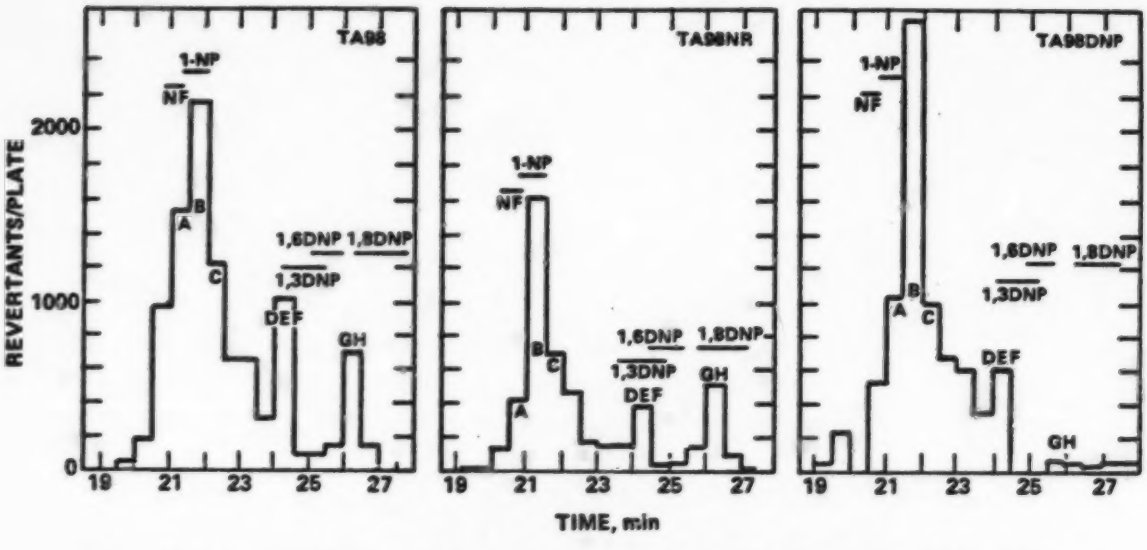

Figure 3. Ames assaychromatograms obtained during the HPLC separation of an extract from particles collected from a light-duty Diesel exhaust. 1-NP,NF, 1,3 , 1,6 and 1,8DNP refer to 1-nitropyrene, nitrofluoranthane, 1,3 , 1,6 and 1,8 dinitropyrenes respectively. TA 98, 98NR, and 98DNP indicate the strains used for detecting mutagens; all data are taken from Ref. 6.

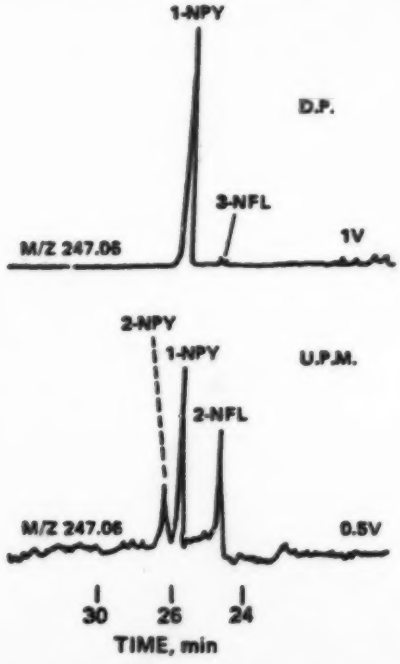

Figure 4. Mass chromatograms of nitropyrene/fluoranthane isomers (m/z:247) recorded during the analysis of subfractions of a Diesel exhaust sample (D.P.) and urban particulate matter sampled in downtown Rome in April when heating was shut-off by law (U.P.M.).

these concentrations add no more than 3 to 4 lung cancer risk to the 7 occurring over 100,000 people each year (7) and this value is one order of magnitude lower than that estimated for people smoking cigarettes, it has to be recalled that more than 100,000 metric tons per year of diesel particles are emitted into our environment and there is a great chance that human carcinogens and direct mutagens can enter into the human body through ways other than inhalation. Therefore, the final task of estimating the actual risk arising from diesel emission is, in our opinion, far from being accomplished as we do not know yet to what extent nitro-PAH, dissociated from particles, can be dispersed in other media, such as water, soil and plants, and, consequently, be assumed by man's body through ingestion and dermal absorption. At the present time, we do not know also if nitro-PAH accumulate in tissues and if they can be a source of acute or chronic disease. We believe that focusing attention into that fraction that can be assumed by inhaling particles does not give a comprehensive view of the problem and a more realistic approach, taking into account multimedia contamination processes, should be followed. This requires that a more extensive work than that presented here has to be carried out in the future. It has to be devoted to confirm our observations and to develop and validate multimedia compartment models capable to predict the risk associated to diesel exhaust emission.

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Jean Parker of the U.S. EPA presented an overview of the EPA's Risk Assessment Forum. She also discussed the recently published guidelines which will be used to ensure consistency and high technical quality in risk assessment investigations.

The EPA'S Forum and Risk Assessment Guidelines, Jean C. Parker

The U.S. Environmental Protection Agency has taken a number of important steps to improve the technical quality and consistency of its evaluation of scientific information in such a manner that it will be reflected in the regulatory decision process. Two of these steps are: (1) the development of Agencywide guidelines for health risk assessment, and (2) the establishment of the Risk Assessment Forum.

Forum

The EPA Risk Assessment Forum was established in 1984 to promote consensus on risk assessment issues, and to ensure that this consensus is incorporated into appropriate risk assessment guidance. To fulfill this purpose, the Forum assembles risk assessment experts from throughout the Agency in a formal process to study and report on these issues from an Agencywide scientific perspective.

The 10 members of the Forum are scientists having experience and expertise in risk assessment and underlying disciplines such as toxicology, chemistry, epidemiology, and statistics. Forum members are selected for staggered 3-year terms by another body, the Risk Assessment Council, recently established to provide oversight for the development, review, and implementation of EPA policy related to risk assessment. The Chair of the Forum, who is one of the 10 Forum members, is appointed by the Administrator.

The Forum staff consists of an Executive Director and science coordinators who are based in the Office of Research and Development. For each activity, the Forum establishes a special committee or a technical panel of scientific experts to conduct scientific review and analysis. Outside experts may also be invited to participate.

Forum activities may include: 1) developing scientific analyses, risk assessment guidance, and risk assessment methodology for use in ongoing and prospective Agency actions; 2) using scientific and technical analysis to propose risk assessment positions; and 3) fostering consensus on these issues. Generally, the Forum focuses on generic issues fundamental to the risk assessment process, the analysis of data used in risk assessment, and developing consensus on approaches to risk assessment. Peer review and quality assurance of completed risk assessments or review of nonscientific risk management issues are not standard Forum functions. Forum actions are referred to the Risk Assessment Council for consideration of policy and procedural issues, and Forum scientific analyses become Agency policy upon recommendation by the Risk Assessment Council and concurrence by the Administrator.

New issues may be proposed at any time. Meetings of the Forum are held on a regular basis, but no less than once each quarter. The meetings are not required to be open to the public.

Forum reports generally receive external peer review. Forum recommendations, scientific analyses, and conclusions are submitted to the Risk Assessment Council for consideration of their use as EPA risk assessment policy.

Guidelines

The U.S. EPA very recently (September 24, 1986) published risk assessment guidelines outlining the approach the Agency uses to evaluate the public health risk of environmental pollutants. Four of the five guidelines relate to health effects: carcinogenicity, mutagenicity, developmental toxicity, and chemical mixtures. The fifth discusses exposure assessment. The primary aim of the guidelines is to promote consistency in EPA risk assessment by developing agencywide consensus on risk assessment methods.

EPA has been a pioneer in developing and adopting risk assessment methodologies and had developed guidelines in the past--the first cancer guidelines appeared as early as 1976. Then when former Administrator Ruckelshaus returned

to EPA, he convened a task force to study ways to improve the scientific foundation for Agency/regulatory decisions. The task force endorsed the view of the National Academy of Sciences, which regards risk assessment and risk management as separate processes, and affirmed the Agency's intent to honor that distinction. The task force also recommended the development of Agencywide risk assessment guidelines to promote consistency and high technical quality in EPA's scientific decisions. The guidelines were developed by workgroups of Agency scientists and submitted to outside experts for comment. Public comment was also solicited.

The guidelines set out EPA's approach to risk assessment as guidance for Agency scientists. They also inform Agency decision makers and the public about EPA risk assessment procedures. The guidelines are, however, living documents, and will be revised as new information and new risk assessment methods become available.

The final presentation in this session was made by Beverly Hanna Thorpe of the Ontario Ministry of the Environment. She discussed the Ministry's approach in developing a scientific criteria document for hazardous environmental contaminants. This approach includes multimedia aspects of the contaminants targeted for investigation.

Development of Multimedia Environmental Standards for Dioxins and Dibenzofurans: A Case Study of the Ontario Ministry of the Environment Approach,
Beverley Hanna Thorpe

In 1982, the Ontario Provincial Ministry of the Environment (Canada) established the Hazardous Contaminants Coordination Branch to coordinate the development of environmental standards, a departure from the traditional approach where air and water standards were developed by independent groups. Since the late 1970's, there has been a growing awareness that a number of persistent and/or ubiquitous chemicals were accumulating in aquatic biota,

birds, and sediment, and have been transported by long-range atmospheric processes. Humans are being exposed to these contaminants by a number of pathways, e.g., food, air, and water. Thus for some environmental contaminants it was decided that a "multimedia" approach to standard setting was required. The development of the scientific criteria document for environmental standards for polychlorinated dibenzo-p-dioxins (PCDD's), and polychlorinated dibenzofurans (PCDF's) provides a case study of this approach.

The Ministry of the Environment's approach to the development of this scientific criteria document is based upon a review of the technical literature published on the PCDD's and PCDF's. All relevant reports and literature were reviewed regardless of apparent quality since the aim of the Committee was to obtain an overall balanced account of the information available.

Estimates and identification of potential or actual concentrations and sources in the province of Ontario were based firstly on data collected in Ontario. This data base is one of the most extensive sets of monitoring data on these chemicals available in the world. Secondly, data from elsewhere in Canada were used and lastly, world data were used where data from the preceding two sources are not available.

Chapter 3 of the criteria document deals with a review and analysis of available toxicological data on the effects of PCDD's and PCDF's. This chapter covers mammalian toxicology, genetic toxicology, carcinogenicity and effects on reproduction, human health effects, and environmental toxicology and the use of the toxic equivalents approach for PCDD's and PCDF's leading to the estimation of the recommended maximum allowable daily intake of PCDD's and PCDF's.

Chapter 4 identifies sources/inputs, distribution, and fate of PCDD's and PCDF's in the environment, especially of Ontario. Chapter 5 attempts to evaluate the exposure risk to the population based on measured and estimated concentrations of PCDD's and PCDF's using the toxic equivalents approach in light of the recommended maximum allowable daily intake. Chapter 6 reviews the current analytical methods and limitations to monitoring PCDD's and PCDF's. Recommendations for research and development to facilitate monitoring of various environmental media and biological effects are given.

This document provides the scientific basis for the development of Provincial standards. Following input of public opinion and legal, policy, and economic considerations (risk assessment) the Ministry will establish the actual standards.

SESSION III. METHODS FOR MULTIMEDIA MANAGEMENT

The third workshop session featured presentations on national strategies for dealing with multimedia environmental contaminants. Toni Schneider of the Netherlands chaired the session. The speakers described their countries' efforts to develop policies and tactics that will provide a holistic approach to the environment and its protection from hazardous contaminants.

The first speaker was Christa Morawa of the Federal Republic of Germany. The FRG does not yet have a national strategy, as laws have been developed on a media-specific basis. However, concern for multimedia management is increasing in the European community, and the FRG has adopted some cross-media standards.

National Strategies Concerning Multimedia Contaminants in the Federal Republic of Germany, Christa Morawa

For historical reasons and for the fact that most of the environmental problems are still to be solved within the "classical" compartments, our environmental pollution control policy is divided into air, water, and waste divisions. The relevant legislation is oriented also toward protecting air and water and organizing waste disposal or incineration. Due to the continuing high pollution of air and surface waters in central Europe, this policy is still valid and has to advance further in the future. This is particularly true for the questions of long-range transboundary air pollution and the pollution of transboundary waterways.

In some respects, air policy has already made a step toward cross-media management. The federal government has set up a soil protection program, where cross-media ideas are introduced. One of the reasons was that deposition from the air along with pollution from agricultural activities plays an important role in soil pollution. The program has been set up only recently, and will be implemented within the next year.

We have set national air pollution deposition standards in 1983 to protect soil and plants as well as food chains and animal fodder from deposition of airborne lead, cadmium, and thallium. These standards are rough figures only based on the small amount of data which were available, but they are a first step towards protecting the soil from the deposition of pollution (Pb: 0,25 mg (m^2d); Cd: 5/ng (m^2d); Th: 10/ng (m^2d)). These standards were exceeded in practice in the vicinity of lead and cadmium processing factories; some years ago a cement factory was found to exceed the thallium standard significantly.

A second example of a cross-media approach is the standards governing the maximum concentration of heavy metals in sewage sludges. Sewage sludge is widely used as fertilizer for agricultural purposes; farmers get it at quite low prices or even without any charge. But in industrialized areas, sewage sludges often have high concentrations of heavy metals. By using it for agricultural purposes, however, maximum allowable values for heavy metals in plants serving as food are exceeded and the products cannot be sold. A maximum lead content of sewage sludge, for example, was set at 1,200 µg/kg along with similar values for other heavy metals.

As another example, the Chemicals Act may be mentioned here. It provides for an assessment of effects of chemical substances on all compartments of the environment.

Internationally, some efforts are being made towards cross-media environmental protection as well. As an example, the activities to protect the North Sea as well as the Baltic Sea are to be mentioned here. In both regions, deposition of pollutants from the air contributes significantly to pollution levels of the seas. Working groups of the Helsinki Commission and the Paris Commission attempt to model the input of pollutants from the air into the sea and calculate their relative contributions. Attempts are made further to set this into relation to land-based pollution. It is not easy to make a distinction between both, because the deposition of air pollutants is more or less equally distributed, while land-based pollution mainly from rivers is more concentrated and much higher near the mouth of the rivers and coastal areas. The overall objective of these activities in the development of a multimedia and multisources management strategy is to protect the North Sea and Baltic Sea from further pollution.

Activities within the UN-ECE focus on the development of binding agreements to reduce emissions of air pollutants in Europe by a certain percentage

within a certain time. Presently, an agreement on the reduction of sulphur emission is in effect and a protocol to reduce NO_x emissions is in preparation.

In both cases, the harmful effects of acid deposition are the cause for working out relevant agreements, a real cross-media approach, because especially effects on soil chemistry are taken into account.

The new directives set by the Commission of the European Communities are more and more directed toward multimedia environmental management. At the moment, a directive on asbestos is in preparation, including all different emission sources and the possible pathways of this toxicant.

The report on Italy's strategy was written by Alexander di Domenico and Francesco Pocchiari of the Istituto Superiore di Sanità in Rome, and was presented by Mr. di Domenico. An industrial accident in Seveso, Italy, in 1976 resulted in severe dioxin contamination over a wide area. This incident and Italy's subsequent cleanup, rehabilitation, and ongoing controlling efforts were described in the presentation. This provides a case study of Italy's approach to developing a multimedia strategy.

Italian Strategy for Dealing with Multimedia Contaminants, Alexander di Domenico and Francesco Pocchiari

Polychlorinated dibenzo-p-dioxins (PCDD's) form a highly heterogenous group of structurally related compounds which are typical multimedia contaminants. The Italian interest in these compounds began in 1976 as a consequence of the ICMESA accident of Seveso that resulted in the contamination by 2,3,7,8-TCDD of about 1800 ha of a densely populated area and required U.S. $150 million and about 10 years of work for rehabilitation. The intense work that was carried on world-wide, particularly after the above-mentioned accident, has recently shown that PCDD's can be formed in significant amounts not only under accidental conditions which may occur in the manufacturing of specific chemicals, but also in a number of rather common situations generally associated with combustion processes.

In the period 1976-1984, the management of risks associated with PCDD's in Italy was focused on prevention of, and response to, accidents potentially involving exposure to 2,3,7,8-TCDD and other toxic substances. At the present, however, this phase has accomplished most of the objectives and the focus is on control of the many sources potentially contributing to the levels of PCDD's which are being detected with increasing frequency in the food chain, in some environmental media, and even in mother's milk.

The ICMESA accident had an enormous impact on approaches to chemical risk management in Italy and world-wide. The lack of information on health-related and environmental-related effects of TCDD and the many coordination problems experienced at national, regional, and local levels as well as between decision-makers and scientific experts, clearly indicated the need for a deep revision of the overall system for chemical risk management in Italy. Therefore, several new regulations dealing broadly with chemicals control or specifically with PCDD's were issued (Table 1) and some structures responsible for implementing these regulations were potentiated.

TABLE 1. LAWS AND REGULATIONS CONCERNING INDUSTRIAL SAFETY AND ENVIRONMENTAL AND OCCUPATIONAL HEALTH BEFORE AND AFTER SEVESO

Object	Period
Use of Toxic Gases	1927
High-pressure Machinery	1927
Production/Storage of Hazardous Materials	1931
Hazardous Industries	1934
Prevention of Industrial Fires	1942 (1961, 1965)
Dangerous Manufacturings	1955, 1959
Occupational Environment	1956
Prevention of Atmospheric Pollution	1966, 1971
Prevention of Water Pollution	1976
Classification, Packaging, and Labeling of Hazardous Industrial Materials	(1974) 1981
Management and Disposal of Toxic and Dangerous Wastes	1982 (1984)
"Seveso Directive" Concerning Prevention of Major Accidents Resulting from Certain Industrial Activities (EEC)*	1982
OECD Council Directive on Transfrontier Movements of Hazardous Waste (EEC)	1984

*Not yet enacted in Italy.

Three EEC Directives have been issued with the aim of preventing the occurrence of unfavorable conditions such as those that caused the ICMESA accident and its aftermath. They are:

1) The EEC Directive 82/501 on the prevention of major risks associated with industrial activities (also referred to as "The Seveso Directive").

2) The VI Amendment (Dir. 79/831) of the EEC Directive 67/548 on the classification, packaging, and labeling of dangerous substances.

3) The Council Directive on transfrontier shipment of hazardous wastes.

Regarding the strengthening of structures responsible for chemicals control, several steps were taken in Italy. As an example at an operational level, in 1978 the National Inventory of Chemical Substances was established at the Istituto Superiore di Sanità in Rome to gather the chemico-physical and toxicological data relevant to assess the health and environmental risk associated with their presence in the environment.

In 1983 the Department of Civil Protection was established to coordinate all activities to respond to emergency situations, and more recently the Ministry of the Environment has been founded.

In the meantime, several regulations or recommendations were issued at a national or regional level with the aim of controlling accidentally-released PCDD's, particularly 2,3,7,8-TCDD. Levels of selected chemical wastes beyond which the refuse is classified as "toxic" have been established in Italy. This classification also entails special precautions for transportation and disposal. According to DM 915, issued on September 10, 1982 and relevant deliberations of July 27, 1984, all wastes containing more than 1 ppb of 1,2,3,6,7,8-hexa-CDD, 1,2,3,7,8,9-hexa-CDD, 1,2,3,7,8-penta-CDD, 2,3,7,8-tetra-CDD (2,3,7,8-TCDD), or 2,3,7,8-tetra-CDF shall be considered toxic. Similarly, all wastes containing more than 500 ppb of total PCDD's or PCDF's shall also be classified as toxic (Table 2).

TABLE 2. SOME "REFERENCE LEVELS" FOR PCDD's AND PCDF's

(A) PCDD's and PCDF's in Wastes: 1,2,3,6,7,8-HxCDD or
1,2,3,7,8,9-HxCDD or
1,2,3,7,8-PeCDD or
2,3,7,8-TCDD or
2,3,7,8-TCDF > 1 ppb → "Toxic"

PCDD or PCDF > 500 ppb → "Toxic"

(B) 2,3,7,8-TCDD in Pesticides (Active Principles) $\leq$ 1 ppb

(C) PCDD's and PCDF's in the Environment:

	2,3,7,8-TCDD	PCDD's + PCDF's
(1) Soil, Crop Growth Permitted	$\leq$ 6 ppt*	$\leq$ 0.75 $\mu g/m^2$
(2) Soil, Crop Growth Forbidden	$\leq$ 40 ppt**	$\leq$ 5 $\mu g/m^2$
(3) Outdoor Building Surfaces	$\leq$ 0.75 $\mu g/m^2$	$\leq$ 0.75 $\mu g/m^2$
(4) Indoor Building Surfaces	$\leq$ 0.01 $\mu g/m^2$	$\leq$ 1 $\mu g/m^2$
	As established by Lombardy region at Seveso	As indicated by National Toxicology Commission

*Equivalent to 0.75 $\mu g/m^2$.

**Equivalent to 5 $\mu g/m^2$.

As visible from point (B), the Italian authorities consider 1 ppb to be the maximum permissible 2,3,7,8-TCDD content in selected pesticides (technically active principles) (DM 27/11/1978). As to group (C) levels, the values of the first column were established in response to the ICMESA plant accident at Seveso (Italy) by local regional authorities.

General environment	2,3,7,8-TCDD
Soil (with permission to grow crops):	6 ppt
Soil (prohibition of crop growing):	40 ppt
Indoor building surfaces:	0.01/$\mu g/m^2$
Outdoor building surfaces:	0.75/$\mu g/m^2$

Recently, the above-mentioned maximum limits have been adopted at a national level in Italy to cover not only 2,3,7,8-TCDD but also all the PCDD's and PCDF's (second column).

The enormous research work carried out recently on the environmental occurrence of PCDD's and related PCDF's has now clearly shown that controlling

dioxins implies much more than prevention of, and response to, chemical accidents. In fact, PCDD's are widely occurring multimedia contaminants which are produced by a number of sources whose relative importance varies according to place and time. Therefore, a new phase has begun aiming at development of a new strategy for controlling these contaminants that have been recently detected even in mother's milk (Tables 3 and 4). At the moment, work is carried out in Italy to clarify what sources need to be controlled (with special emphasis on incineration of solid wastes and sludges), to minimize releases into the environment, and understand the environmental significance of exposure to highly complex mixtures of PCDD's and PCDF's such as those detected so far in the environment.

TABLE 3. DAILY INTAKE OF TCDD-EQUIVALENTS FROM HUMAN MOTHER'S MILK (BASED ON ANALYTICAL DATA FROM RAPPE 1985). THE DAILY INTAKE IS CALCULATED FOR A 5 kg BABY CONSUMING 850 mL MILK PER DAY

Milksample (fat level)		Daily Intake (picogram/kg)		
		Method 1	Method 2	Method 3
Sweden	1 (2.2%)	38.1	15.9	27.5
	2 (2.5%)	92.8	37.4	68.0
	3 (4.3%)	159.8	54.3	89.8
	4 (1.8%)	25.7	11.8	21.3
Germany	1 (4.6%)	158.1	55.2	84.6
	2 (4.6%)	218.7	83.2	134.0
	3 (2.7%)	189.7	67.3	104.0
	4 (2.5%)	135.7	53.9	83.6
	5 (2.5%)	106.4	39.6	57.9

Method 1. Eadon et al., 1982.

2. U.S. Environmental Protection Agency, 1984.

3. Denmark, 1984.

TABLE 4. INTAKE OF CHLORINATED COMPOUNDS VIA MOTHER'S MILK*
(MILK INTAKE 150 mL/kg BODY WEIGHT AND DAY)

Compound	Level in milk µg/l	Daily intake µg/kg bw	Estimated tolerable daily intake (TDI) µg/kg bw	Ratio intake/ TDI
DDT	25	3.8	20	0.2
PCB's	20	3	0.1-0.01	3-30
PCDD's/PCDF's as TCDD-equiv	0.000 2	0.000 03	0.000 001-0.000 010	3-30

* = Based on very rough mean figures from Dutch and Swedish data.

In his presentation, Yasushi Kodama of the Japan School of Medicine focused on the reduction of air pollutants as an example of the nation's approach to multimedia strategy.

Air Pollution Control in Japan, Yasushi Kodama

Due to the rapid industrialization and motorization in Japan, the problem of environmental pollution has been of great concern since the 1960's. The staffs of universities and institutes in Japan have been observing air pollutants and studying the health effects of air pollutants since then. However, these studies have focused mainly on the amounts of dust fall, the ambient concentrations of SO_2, and CO, and the ailments caused by SO_2, such as chronic bronchitis. In 1965, the National Air Monitoring Network (NAMN) was established in three cities--Tokyo, Osaka, and Amagasaki, and the routine sampling of suspended particulates using a High-Volume air sampler and the analysis of metals have begun.

On the other hand, as technical countermeasures to reduce the contaminants from smokestacks and automobiles were considered and developed, the concentration of dust, SO_x, NO_x, CO, PAH, and metals in the atmospheric environment

decreased. In this presentation, the transition of air pollution and the countermeasures for air pollution in Japan are explained by using data from the Environmental Agency and our data in Kitakyushu city, which is one of the largest industrial areas in Japan. These data show a remarkable decrease of air pollutants.

cf. Kitakyushu city

dust fall	64.0 ton/km^2/M (1959)----9.8 ton/km^2/M (1982)
SO_2	0.032 ppm (1967)---------0.006 ppm (1982)
Pb	0.355 μg/m^3 (1970)-------0.081 μg/m^3 (1983)
Cd	0.006 μg/m^3 (1970)-------0.001 μg/m^3 (1981)

Therefore, to clarify the state of air pollution and to gather the raw data needed for Environmental Quality Standards and pollution control programs, NAMN (N=15), and prefectural or city institutes constantly monitor the environmental pollutants.

In order to control the pollution, "Basic Law for Environmental Pollution Control" (1967) and "Air Pollution Control Law" (1968) were promulgated and enforced. Under these laws, municipalities and factories in Japan have considered various countermeasures to reduce ambient air pollutants. For instance, a) conversion of fuel from coal to oil in order to reduce dust fall and suspended particulates, b) the use of fuel which contained a low percentage of sulfur, c) application of dust collectors and desulfurizers for smokestacks, d) catalytic conversion of nitrogen oxides to nitrogen or decreasing the combustion temperature in furnaces to less than 1,000°C, e) use of lead-free gasoline for automobiles, f) "K-value regulation" of sulfur oxides $q=K \times 10^{-3} \times He^2$, and g) others.

The Environmental Quality Standards in Japan are as follows:

Ambient Air Quality Standards

Substance	Standard values
Sulfur dioxide	Daily average of hourly values shall not exceed 0.04 ppm, and hourly values shall not exceed 0.1 ppm.
Carbon monoxide	Daily average of hourly values shall not exceed 10 ppm, and average of hourly values in eight consecutive hours shall not exceed 20 ppm.
Suspended particulate matter	Daily average of hourly values shall not exceed 0.10 mg/m^3, and hourly values shall not exceed 0.20 mg/m^3.
Nitrogen dioxide	Daily average of hourly values shall be within the range between 0.04 ppm and 0.6 ppm or below.
Photochemical oxidants	Hourly values shall not exceed 0.06 ppm.

The monitoring data of NAMN show that the ambient levels of pollutants, except NO_2, are lower than standard in most of the areas of Japan. However, the number of monitoring stations exceeding the upper standard limit of 0.06 ppm of NO_2 was 2 percent of the total effective monitoring stations in 1983.

In consideration of these circumstances, national strategies for air pollution control in Japan will be directed to NO_x from automobiles, exhaust from diesel engines, and fly ash emitted from stacks, as the use of coal at power plants is being considered more and more because of the lack of natural resources.

In Japan, continuous efforts to keep ambient air clean are made from both scientific and administrative viewpoints.

The Netherlands national strategy was described by C. A. van der Heijden of the National Institute of Public Health and Environmental Hygiene. The Netherlands develops a multimedia assessment document for every chemical compound it plans to regulate.

Safety Evaluation of Hazardous Chemicals in the Human Environment, C. A. van der Heijden

Ideally, a multimedia approach to hazardous chemicals in the human environment should result in a concentration of a compound in food, air, or drinking water which would not pose any hazard to the human population. Apart from the protection of humans, consideration also should be given to possible adverse effects on various environmental compartments.

The main problem in safety assessment is lack of detailed knowledge of a given chemical, such as detailed knowledge of dose-response relationships in experimental animals and humans, sources and levels of exposure, possible interactions, sensitive populations, and the existence or nonexistence of a threshold for specified toxic effects. Generally, relevant data are scarce; therefore, scientific judgement, including uncertainty, plays an important and unavoidable role in establishing safe or acceptable levels. However, despite the many uncertainties a scientific consensus can be reached in establishing safe levels for the various compartments from which humans may be exposed.

In The Netherlands, various ministries are involved with regulation of chemicals, e.g., environmental hygiene, health, occupational hygiene, and agriculture. There is good cooperation among these ministries in regulating national and international committees (e.g., EC, WHO), which is a sound basis for considering a multimedia approach.

The National Institute of Public Health and Environmental Hygiene (RIVM) has the task to prepare the scientific documentation and to propose standards to protect human health and the environment. This unique position gives the opportunity to integrate and to consider the various routes of exposure, total exposure to a given chemical, and the existence of special risk groups.

The documents prepared by the RIVM contain the summarized data on:

- chemical aspects, e.g., occurrence, use, emissions, residues
- exposure assessment for various routes and media
- toxicology, e.g., metabolism, kinetics, animal data, human data
- evaluation and risk assessment
- proposals for standards to protect human health, e.g., ADI, limit values, water/air quality guidelines and ecotoxicological safe levels (soil, water)

In the recent years, multimedia assessment documents have been prepared for a number of chemicals: acrylonitrile, ethylene oxide, propylene oxide, 1,2-dichloroethane, epichlorohydrine, vinyl chloride, chloroform, trichloroethene, tetrachloroethene, CCl_4, methylene chloride, fine particles, styrene, benzene, cadmium, nitrate/nitrite, Beta-HCH, 2,3,7,8 TCDD.

The last presentation in this session was by Si Duk Lee of the U.S. EPA. The United States traditionally has addressed pollution problems by single-medium approaches and regulations. The need to integrate these approaches has become increasingly clear, and the EPA has now developed an Integrated Environmental Management Program.

U.S. EPA Strategy for Cross-Media Environmental Management, Si Duk Lee

The National Environmental Policy Act of 1969 mandated interdisciplinary management of environmental pollution problems by all agencies of national government. A similar mandate to deal with complex problems of multimedia pollution would have been very useful; however, it does not exist to date. In conjunction with the consideration of interdisciplinary management of environmental problems, Daniel Dreyfus (1970) stated that "the government agencies are structured to address single-purpose, problem-oriented programs or missions." The same problem plagues multimedia management. The 1983 report by the National Academy of Sciences (NAS) on "Risk Assessment and Risk Management" provided

a very useful guide to public health and environmental protection officials (Figure 1). The report clarified the distinction between scientific assessment of the nature and extent of health and environmental hazards, and the role of regulatory decision-makers determining the most appropriate responses to those problems.

Figure 1. Risk assessment and risk management.

The U.S. EPA has adopted and is implementing many of the recommendations included in the NAS report to strengthen the scientific basis for assessing environmental risk(s) upon which regulatory decisions are made, and what is done to reduce that risk in the most effective manner. However, program integration has always been a problem for EPA leadership because of the diverse mandates of the Agency. Nevertheless, such integration of environmental programs was one of the reasons for establishing EPA in the first place. Lack of coordination has often led to management difficulties, including: duplicative research on the same substance; different programs producing

different risk assessment for the same substance; unwitting transfer of pollutants from one environmental medium to another via pollution control technology; uncoordinated regulation of the same industry or the same substance by different programs; and seemingly different risk management decisions from different programs on the same substance.

For historical perspective, it should be useful to quickly review what conventional single-medium approaches to mitigate environmental pollution problems have accomplished. Rivers were catching fire; lakes and rivers were so polluted, swimming and fishing had to be prohibited; the population of bald eagles and some fish were at dangerous levels. Under such circumstances, the control agencies had to take rapid remedial actions to remove large amounts of contaminants from polluted air and water. Such actions produced some marked improvements in our environment. For example, between 1975 and 1982, in spite of the increase in both our population and gross national products, we were able to reduce major pollutants significantly: particulate matter was reduced by 27%; carbon monoxide by 31%; sulfur dioxide by 33%; ozone by 18%; no change in nitrogen dioxide, and the case of lead, we achieved 74 percent reduction by 1984. The levels of almost all important pollutants in most metropolitan areas have been reduced during this period. Similarly, impressive records can be seen in water pollution control. We provided municipal sewage treatment for over 80 million people since 1970. Water pollution control devices have been installed in most industrial plants, and this resulted in a 38 percent decrease in the organic waste releases. The U.S. Environmental Protection Agency has issued almost all the required effluent guidelines. When all these control measures are implemented, discharges of toxic pollutants are expected to be reduced 96 percent from 1972 levels.

Therefore, this kind of effort will continue in accordance with the Congressional mandates; however, based on our collective experience in the single-medium approaches to remove contaminants from the individual medium, a need for a holistic cross-media approach of controlling our pollution problems became apparent.

In concert with the efforts of NAS, the U.S. EPA has developed Multimedia Risk Assessment Methodologies along with an Integrated Environmental Management Program. These programs were developed primarily in response to the novel problems posed by the presence of toxic chemicals in our environment.

The U.S. EPA intends to make the Agency a more efficient protector of our health and environment, and the Agency plans to achieve this by:

1. establishing scientific and rational pollution control priorities,

2. assessing the economic impact of control options; and

3. developing options for Agency management that array pollution control strategies in terms of cost-effectiveness.

In support of such multimedia risk management, the Agency has developed a multimedia risk assessment approach to study the control of toxic chemicals. This is an analytical methodology that can be used to identify cost-effective regulatory approaches in diverse Agency applications. This approach integrates quantitative estimates of the health and environmental effects of toxic chemical releases and examines alternative regulatory options which result in different degrees of health risk and costs with the aid of modeling. This approach allows selection of an appropriate regulatory strategy based on the degree of risk reduction.

AGENDA
NATO/CCMS WORKSHOP ON
MULTIMEDIA APPROACHES TO ASSESSMENT AND MANAGEMENT OF HAZARDOUS AIR CONTAMINANTS

Wednesday, October 8

8:30-9:30	Registration	
DEFINING THE CHALLENGE		C. Morawa, Workshop Co-chair, FRG
9:30	NATO/CCMS Welcome and Session Opening	C. Morawa
9:35	Welcome to Denver and Region 8	M. Dodson, Region 8
9:40	Workshop Announcements	V. Bradow
9:45	Introductory Remarks: "New Challenges for the Air Pollution Professional"	M. Berry, Workshop Co-Chair, USA
9:50	Keynote Talk: "Scoping the Problem"	J. Spengler
10:20	Break	
10:45	Summary of the Scientific Consensus on Lead	D. Weil
12:00	Lunch	
1:00	Case Studies in Multimedia Management of Lead	M. Piscator, Chair
	Boston, Massachusetts	P. Ciriello
	Bunker Hill, Idaho	I. von Lindern
	Japan	G. Ohi
	FRG	E. Weber
	Piedmont, Italy	S. Facchetti
3:30	Break	
4:00	Introducing Uncertainty; Implications for Approaches and Strategies	R. Hartung
4:30	Discussion	
5:00	Adjourn	

Thursday, October 9

METHODS FOR MULTIMEDIA ASSESSMENT		M. Piscator, Chair
8:30	Berlin Pollution Atlas	F. Ellermann
	From Computer-Aided Mapping to Ecological Information System	M. Bock
	Geographic Information System (includes demonstration)	M. von Braun
10:00	Break	
10:15	Information Bases for Analysis and Interpretation of Population Survey Studies	M. Piscator
	Multimedia Enforcement Investigations (includes mobile lab demonstration)	J. Hatheway
12:00	Lunch	
1:00	Lower Elbe Regional Project	H. Davidsohn
	Evaluation of Human Carcinogens from Diesel Exhaust	P. Ciccioli
	The EPA Forum and Risk Assessment Guidelines Series	J. Parker
	Development of Multimedia Environmental Standards for Dioxin and Dibenzofuran: A Case Study of the Ontario Ministry of the Environment	B. Hanna Thorpe
2:30	Discussion	
3:00	Break	
METHODS FOR MULTIMEDIA MANAGEMENT		T. Schneider, Chair
3:15	National Strategies for Dealing with Multimedia Contaminants:	
	FRG	C. Morawa
	Italy	A. di Domenico
	Japan	Y. Kodama
	The Netherlands	C. A. von der Heijden
	U.S	S. D. Lee
4:30	Discussion, Panel and Participants	
5:30	Adjourn	

Friday, October 10

SUMMARY AND SYNTHESIS		C. Morawa, M. Berry, Co-chairs
8:30	Summary by Workshop Rapporteur	T. Schneider
9:15	Discussion, Development of Proposed Recommendations	R. Bauman
10:15	Break	
10:30	Development of Proposed Recommendations, continued	
11:00	Wrap-up by Conference Co-Sponsors	C. Morawa, M. Berry
11:30	Adjourn	

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